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October 2000

# DELTA IV

# Payload Planners Guide

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# PAYLOAD PLANNERS GUIDE

The Delta IV Payload Planners Guide has been cleared for public release by the Chief—Air Force Division, Directorate for Freedom of Information and Security Review, Office of the Assistant Secretary of Defense, as stated in letter 00-S-3366, dated 27 September 2000.

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## CHANGE RECORD

| Revision Date | Version | Change Description |
|---|---|---|
| October 2000 | 2000 | Section 1 – Updates include:<br>■ Revised Launch Vehicle discussion |
| | | Section 2 – Updates include:<br>■ Updated performance curves of all Delta IV vehicle configurations |
| | | Section 3 – Updates include:<br>■ Updated static payload envelopes for all fairing<br>■ Added static payload envelop for new 1575-mm interface PAF |
| | | Section 4 – Updates include:<br>■ Updated Eastern Range and Western Range facility environments<br>■ Updated radiation and electromagnetic environments<br>■ Updated figures for fairing pressure envelope<br>■ Updated figures for payload environments: thermal, steady-state acceleration, acoustic, shock |
| | | Section 5 – Updates include:<br>■ Added new 1575-mm dia interface PAF<br>■ Updated PAFs discussion<br>■ Updated figures for PAFs |
| | | Section 6 – Updates include:<br>■ Updated launch site facilities discussion<br>■ Revised figures for launch site facilities<br>■ Revised Launch Control Center discussion<br>■ Revised launch integration schedule |
| | | Section 7 – Updates include:<br>■ Updated launch site facilities discussion<br>■ Updated California Spaceport facilities discussion<br>■ Revised figures for launch site facilities<br>■ Revised launch integration schedule |
| | | Section 8 – Updates include:<br>■ Revised figures for Mission Integration process<br>■ Revised Table 8-4, Spacecraft Questionaire |
| | | Section 9 – Updates include:<br>■ Revised Safety requirements discussion |
| | | Appendixes – Updates include:<br>Appendix A – Updates lightning launch commit criteria discussion<br>Appendix B – Updated Payload Safety Requirements<br>Appendix C – Revised history of flight mission accomplishments |

# PREFACE

This Delta IV Payload Planners Guide (PPG) is issued to the spacecraft user community to provide information about the Delta IV family of launch vehicles and their related systems and launch services.

This document contains current information on Boeing plans for Delta IV launch services in addition to current projections related to the Delta launch vehicle specifications. Included are Delta IV family vehicle descriptions, target vehicle performance figures, payload envelopes, anticipated spacecraft environments, mechanical and electrical interfaces, payload processing, and other related information of interest to our potential customers.

As the Delta IV development program progresses, The Boeing Company will periodically update the information presented in the following pages. To this end, you are urged to promptly mail back the enclosed Readers Service Card so that you will be sure to receive any updates as they become available.

Recipients are also urged to contact Boeing with comments, requests for clarification, or amplification of any information in this document.

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## GLOSSARY

| | |
|---|---|
| 1SLS OB | 1st Space Launch Squadron Operations Building |
| 30SW | 30th Space Wing |
| 45SW | 45th Space Wing |
| A/C | air-conditioning |
| AASHTO | American Association of State Highway and Transportation Officials |
| AC | alternating current |
| ACS | attitude control system |
| AFB | Air Force Base |
| AFSMC | Air Force Space & Missile Center |
| AGE | aerospace ground equipment |
| AKM | apogee kick motor |
| ANSI | American National Standards Institute |
| ASO | Astrotech Space Operations, LP |
| AST | Associate Administration for Commercial Space Transportation |
| AT | access tower |
| ATP | authority to proceed |
| AWG | American Wire Gage |
| AZ | azimuth |
| B&W | black and white |
| BAS | breathing air supply |
| B/H | blockhouse |
| BPS | bits per second |
| BSM | booster separation motor |
| CAD | computer-aided design |
| CBC | common booster core |
| CCAFS | Cape Canaveral Air Force Station |
| CCAM | contamination and collision avoidance maneuver |
| CCTV | closed-circuit television |

| | |
|---|---|
| CCW | counter-clockwise |
| CDR | critical design review |
| CFR | Code of Federal Regulations |
| CG | center of gravity |
| CL | centerline |
| C/O | checkout |
| COMSTAC | Commercial Space Transportation Advisory Committee |
| CPF | Centaur processing facility |
| CRD | command receiver decoder |
| CSB | common support building |
| CWA | clean work area |
| DBL | dynamic balance laboratory |
| DC | direct current |
| DE | director of engineering |
| DID | data item description |
| DIV-H | Delta IV Heavy |
| DIV-M | Delta IV Medium |
| DIV-M+ | Delta IV Medium-Plus |
| DLPS | Delta launch processing system |
| DLS | Delta Launch Services |
| DMCO | Delta Mission Checkout |
| DOC | Delta Operations Center |
| DOD | Department of Defense |
| DOF | degrees of freedom |
| DOT | Department of Transportation |
| DPAF | dual-payload attach fitting |
| DPC | dual-payload canister |
| DPF | DSCS Processing Facility |
| dps | dispersions per second |

DSCS — Defense Satellite Communications System

DTO — detailed test objectives

E/W — east/west

E&O — engineering and operations

EAL — entry authority list

ECS — environmental control system

EED — electro-explosive device

EELV — evolved expendable launch vehicle

EGSE — electrical ground support equipment

EHD — engineering hardware description

EIRP — effective isotropic radiated power

ELS — expendable launch system

ELV — expendable launch vehicle

EMC — electromagnetic compatibility

EMI — electromagnetic interference

EMT — electrical-mechanical testing

EPT — elevating platform transporter

ER — Eastern Range

ESA — engineering support area; explosive safe area

ESM — erectable service mast

ESS — electronic security system

EWR — Eastern and Western Ranges

FAA — Federal Aviation Administration

FDLC — final design loads cycle

FED-STD — federal standard

FMA — final mission analysis

FO — fiber-optic

FOTS — fiber-optic transmission system

FPE — fixed platform erector

FRR — flight readiness review

FS — first stage

FSAA — fairing storage and assembly area

FTS — flight termination system

FUT — fixed umbilical tower

GC — guidance computer

GC&NS — guidance control & navigation system

$GC^3ME$ — ground command, control, communication, and mission equipment

GEM — graphite-epoxy motor

GEO — geosynchronous Earth orbit

GMT — Greenwich mean time

$GN_2$ — gaseous nitrogen

GOP — ground operations plan

GPS — global positioning system

GSA — gas storage area

GSE — ground support equipment

GSFC — Goddard Space Flight Center

GTO — geosynchronous transfer orbit

H/H — hook height

HB — Huntington Beach (California)

HEPA — high-efficiency particulate air

HIF — horizontal integration facility

HIP — hot isostatic press

HLV — heavy launch vehicle

HPF — hazardous processing facility; hydrogen processing facility

HPTF — hazardous processing testing facility

HPU — hydraulic pump unit

HVAC — heating, ventilating, and air conditioning

I/F — interface

IACO ____ integration and checkout

IBD ____ inhabited building distance

ICD ____ interface control drawing

IIP ____ instantaneous impact point

IL ____ interline distance

IPA ____ isopropyl alcohol

IPF ____ integrated processing facility

IPT ____ integrated product team

IRIG ____ Interrange Instrumentation Group

$I_{SP}$ ____ specific impulse

IVA ____ immediate visual assessment

J-box ____ junction box

KMI ____ KSC Management Instruction

KSC ____ Kennedy Space Center

LAN ____ local area network

LCC ____ launch control center

LDA ____ launch decision authority

LEA ____ linear explosive assembly

LEO ____ low-Earth orbit

$LH_2$ ____ liquid hydrogen

LMU ____ launch mate unit

$LO_2$ ____ liquid oxygen

LOCC ____ launch operations control center

LOP ____ launch operations plan

LPD ____ launch processing document

LPT ____ lightning protection tower

LRB ____ liquid rocket booster

LRR ____ launch readiness review

LSIM ____ launch services integration manager

LSRR ______ launch site readiness review
LSS ______ launch site support
LSSM ______ launch site support manager
LSTP ______ launch site test plan
LT ______ launch table
LSS ______ launch support shelter
LV ______ launch vehicle
LVC ______ launch vehicle contractor
LVCS ______ launch vehicle coordinate system
LVDC ______ launch vehicle data center
MAS ______ mobile assembly structure
MCC ______ main combustion chamber
MCC-1 ______ Marshall convergent coating
MD ______ mission director
MDA ______ McDonnell Douglas Aerospace
MDC ______ McDonnell Douglas Corporation; Mission Director Center
MECO ______ main-engine cutoff
MEOP ______ mean expected operating pressure
MIC ______ meets-intent certification
MIL ______ military
MIL-STD ______ military standard
MLV ______ medium launch vehicle
MOI ______ moment of inertia
MPPF ______ multipayload processing facility
MSL ______ mean sea level
MSPSP ______ missile system prelaunch safety package
MSR ______ mission support request
MST ______ mobile service tower
N/A ______ not applicable; not available

N/S ____ north/south

NASA ____ National Aeronautics and Space Administration

NCS ____ nutation control system

NLT ____ not later than

NMM ____ national mission model

NOAA ____ National Oceanographic and Atmospheric Administration

NPF ____ Navstar processing facility

NUS ____ no upper stage

NVR ____ nonvolatile residue

OASPL ____ overall sound pressure level

OB ____ operations building

OH ____ overhead

OR ____ operations requirement

OSB ____ operations support building

OVS ____ operational voice system

P&C ____ power and control

P/N ____ part number

PA ____ payload adapter

PACS ____ payload accommodations coordinate system

PAF ____ payload attach fitting

PAM ____ payload assist module

PC ____ personal computer

PCC ____ payload checkout cell

PCES ____ portable clean environmental shelter

PCL ____ precision clean lab

PCM ____ pulse code modulation

PCS ____ probability of command shutdown

PDD ____ payload database document

PDR ____ preliminary design review

PEA ____ payload encapsulation area

PECS ____ portable environmental control system

PEF ____ payload encapsulation facility

PGOC ____ payload ground operations contract

PHE ____ propellant handler's ensemble

PHPF ____ payload hazardous processing facility

PL, P/L ____ payload

PLA ____ payload accommodations

PLF ____ payload fairing

PMA ____ preliminary mission analysis

PPF ____ payload processing facility

PPG ____ payload planners guide

PPR ____ payload processing room

PPRD ____ payload processing requirements document

PRD ____ program requirements document

PSM ____ program support manager

PSP ____ program support plan

PSSC ____ pad safety supervisor's console

PTR ____ public transportation route

PWU ____ portable weight unit

Q ____ dynamic pressure

QD ____ quick disconnect

RACS ____ redundant attitude control system

RCO ____ range control officer

RCS ____ reaction control system

$R_E$ ____ equatorial radius

RF ____ radio frequency

RFA ____ radio frequency application

RFI ____ radio frequency interference

RGA ____ rate gyro assembly

RH ____ relative humidity

RIC ____ receipt inspection center

RIFCA ____ redundant inertial flight control assembly

RIS ____ receipt inspection station

RLCC ____ range launch control center; remote launch control center

ROC ____ range operations commander

ROCC ____ range operations control center

ROS ____ range operations specialist

S&A ____ safe and arm

S&G ____ Sargent and Greenleaf

S/C, SC ____ spacecraft

SA ____ swing arm

SAB ____ satellite assembly building

SAEF ____ spacecraft assembly and encapsulation facility

SCAPE ____ self-contained atmosphere protection ensemble

SE ____ support equipment

SEB ____ support equipment building

SECB ____ security entry control building

SECO ____ second-stage engine cutoff

SEIP ____ standard electric interface panel

sigma (σ) ____ standard deviation

SIP ____ standard interface plane

SLC ____ Space Launch Complex

SLS ____ Space Launch Squadron

SMC ____ Space and Missile Systems Center

SOB ____ squadron operations building

SOP ____ standard operating procedure

SPIF ____ Shuttle payload integration facility

SR&QA _____ safety, reliability, and quality assurance; safety requirements and quality assurance

SRM _____ solid rocket motor

SSI _____ Spaceport Systems International

SSME _____ Space Shuttle main engine

STA, Sta _____ station

STD _____ standard

STS _____ Space Transportation System

SV _____ space vehicle

SVAFB _____ South Vandenberg Air Force Base

SVC _____ space vehicle contractor

SVIP _____ space vehicle interface panel

SW _____ software; Space Wing

SW/CC _____ Space Wing Commander

T/M _____ telemetry

TBD _____ to be determined

TBR _____ to be revised

TDRSS _____ tracking and data relay satellite system

TECO _____ third-stage engine cutoff

THD _____ total harmonic distortion

TIM _____ technical interchange meeting

TMR _____ telemetry control rack

TMS _____ telemetry system

TOPS _____ transistorized operational phone system

TT&C _____ telemetry, tracking, and command

TV _____ television

TVC _____ thrust vector control

UDS _____ universal document system

UHF _____ ultra-high frequency

UPS _____ uninterruptible power supply

US, U.S. ____ upper stage, United States
USAF ____ United States Air Force
UV ____ ultraviolet
VAB ____ vertical assembly building
VAC ____ volts alternating current
VAFB ____ Vandenberg Air Force Base
VC ____ visible cleanliness
VCA ____ vehicle checkout area
VCF ____ vehicle checkout facility
VCR ____ vehicle control rack
VDC ____ volts direct current
VDL ____ voice direct line
VIM ____ vehicle information memorandum
VLC ____ verification loads cycle
VM ____ video monitor
VOS ____ vehicle on stand
VPF ____ vertical processing facility
VRR ____ vehicle readiness review
W/D ____ walkdown
W/O ____ without
WR ____ Western Range

# INTRODUCTION

This payload planners guide describes the Delta IV launch system including its heritage, performance capabilities, and payload environments. Additionally, launch facilities and operations are discussed, as well as documentation and procedural requirements associated with preparing and conducting the launch.

The Delta IV configurations described herein are the latest evolution of our reliable Delta family, developed to provide our customers low-cost access to space. In four decades of use, Delta launch systems have succeeded through evolutionary design upgrades to meet the growing needs of the user community while maintaining high reliability.

Delta IV launch vehicles can be launched from one of two launch sites within the continental U.S.—Eastern Range (ER) in Florida, and Western Range (WR) in California, depending on mission requirements. Our Space Launch Complex (SLC) of the ER, designated SLC-37, is located at Cape Canaveral Air Force Station (CCAFS) and is used for geosynchronous transfer orbit (GTO) missions as well as missions requiring low- and medium-inclination orbits, while our SLC-6 of the WR at Vandenberg Air Force Base (VAFB) is typically used for high-inclination orbit missions. Both launch complexes are currently under construction with SLC-37 expected to be operational in 2001 and SLC-6 in 2002.

As a commercial launch services provider, Boeing acts as the coordinating agent for the customer in interfacing with the United States Air Force (USAF), National Aeronautics and Space Administration (NASA), the Federal Aviation Administration (FAA), and any other relevant agencies. Commercialization agreements with the USAF and NASA make available to Boeing the use of launch facilities and services for Delta IV launch campaigns.

During the first quarter of 1999, the transition of McDonnell Douglas Commercial Delta, Inc., to Delta Launch Services, Inc., was completed. As part of this reorganization, we have designed Delta Launch Services (DLS) to improve customer satisfaction, provide a single point of contact, and increase responsiveness. Delta Launch Services offers full-service launch solutions using the Delta II, Delta III, and Delta IV family of launch vehicles. The customer is supported by an integrated product team (IPT)-based organization consisting of highly knowledgeable technical and managerial personnel who are dedicated to open communication and responsive to all customer needs (Figure 1).

Delta Launch Services has the ultimate responsibility, authority, and accountability for all Delta customer opportunities. This includes developing launch solutions to meet customer needs as well as providing customers with a launch service agreement for the selected launch services. It is through the DLS organization that dedicated focal points of contact are assigned to customers to

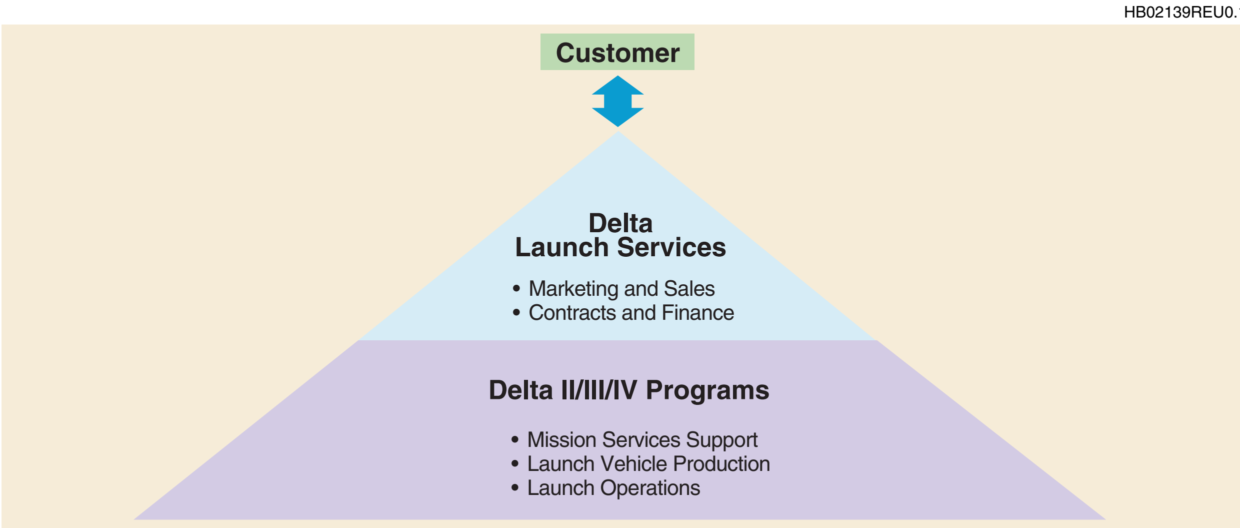


**Figure 1. Delta Launch Services Organization**

ensure that all the launch service needs are coordinated with the appropriate sales, marketing, contracts, and technical personnel.

Delta Launch Services and the Delta IV program office work together to ensure that customer requirements are met. The Delta IV program is responsible for the development, production, integration, test, mission integration, and launch of the Delta IV system.

For contracted launch services, a dedicated mission integration manager is appointed from within the Delta IV program to support each customer. The mission integration manager also works with DLS early in the process to ensure understanding of customer mission requirements and the proposed launch solution. From contract award through launch and postflight analysis, the mission integration manager provides the day-to-day mission integration support necessary to successfully satisfy the customer's launch requirements.

The Delta team addresses each customer's specific concerns and requirements, employing a meticulous, systematic, user-specific process that addresses advance mission planning and analysis of payload design; coordination of systems interface between payloads and Delta IV; processing of all necessary documentation, including government requirements; prelaunch systems integration and checkout; launch-site operations dedicated exclusively to the user's schedule and needs; and comprehensive postflight analysis.

The Delta team works closely with its customers to optimize the payload's operational life. In many cases, we can provide innovative trades to augment the performance values shown in Section 2. Our demonstrated capability to use the flexibility of the Delta launch vehicle and design team, together with our experience in supporting customers worldwide, makes Delta the ideal choice as a launch services provider.

The Delta IV launch system offers single- as well as dual-manifest launch services and the benefits of a launch team committed to each user's payload with a mission profile and launch window designed for specific mission orbits. Delta's manifesting provides exceptional cost control and overall efficiency, simplified integration processes, on-time launch assurance, and efficient flight operations. Furthermore, our dual- and multiple-manifest systems provide customers the autonomy similar to a dedicated launch with price economies of a shared launch. Coupled with these launch service attributes is the Boeing commitment to excellence and proven dependability which, for more than four decades, has given our customers the highest assurance of a successful launch campaign.

# *Section 1*
# *LAUNCH VEHICLE DESCRIPTION*

This section provides an overall description of the Delta IV launch system and its major components. In addition, Delta IV vehicle designations are explained.

## 1.1 DELTA LAUNCH VEHICLES

The Delta launch vehicle program was initiated in the late 1950s by the National Aeronautics and Space Administration (NASA). The Boeing Company, then McDonnell Douglas (previously Douglas Aircraft Missiles and Space Systems), was the prime contractor. Boeing developed an interim space launch vehicle using a modified Thor missile as the first stage and Vanguard components as the second and third stages. The vehicle was capable of delivering a payload of 54 kg (120 lb) to geosynchronous transfer orbit (GTO) and 181 kg (400 lb) to low-Earth orbit (LEO). For over four decades, Boeing has continuously improved its launch vehicles to meet customers' growing needs.

Boeing's dedication to delivering superior launch service to its customers is evidenced by the many configurations available (Figure 1-1). The Delta family of launch vehicles has the capability of delivering a wide range of payload classes to orbits. Delta II has provided customers with a demonstrated world-class success rate of 97.8%, and processing times on the launch pad have been reduced from 40 to 24 days. The Delta III launch vehicle continued the improvement tradition by providing a GTO capability of 3810 kg (8400 lb) and a LEO capability of 8292 kg (18,280 lb). The Delta IV launch system is the latest example of this 40-year evolution, providing even more capability at a lower cost by incorporating heritage hardware and processes with a new robust propulsion system. Boeing is committed to working with our customers to satisfy payload requirements while providing the best value for launch services across the entire Delta fleet.

## 1.2 DELTA IV LAUNCH SYSTEM DESCRIPTION

The newest member of the Delta family is the Delta IV launch system, which comes in five vehicle configurations: the Delta IV Medium (Delta IV-M), three variants of the Delta IV Medium-Plus (Delta IV-M+), and the Delta IV Heavy (Delta IV-H), as shown in Figures 1-2 and 1-3. Each has a newly developed first-stage, called the common booster core (CBC) using cryogenic propellants (liquid oxygen, $LO_2$/liquid hydrogen, $LH_2$). Figure 1-2 shows the evolution of the Delta IV launch vehicle system from our heritage Delta II and Delta III programs.

- The Delta IV-M employs a first-stage CBC, a 4-m (157.5-in.)-dia cryogenic second stage, and a 4-m (157.5-in.)-dia composite payload fairing (PLF).

- The Delta IV-M+ comes in three different configurations. One configuration uses two strap-on solid rocket motors (SRMs) to augment the first-stage CBC, a 4-m (157.5-in.)-dia cryogenic second stage, and a 4-m (157.5-in.)-dia composite payload fairing (PLF). This configuration is designated

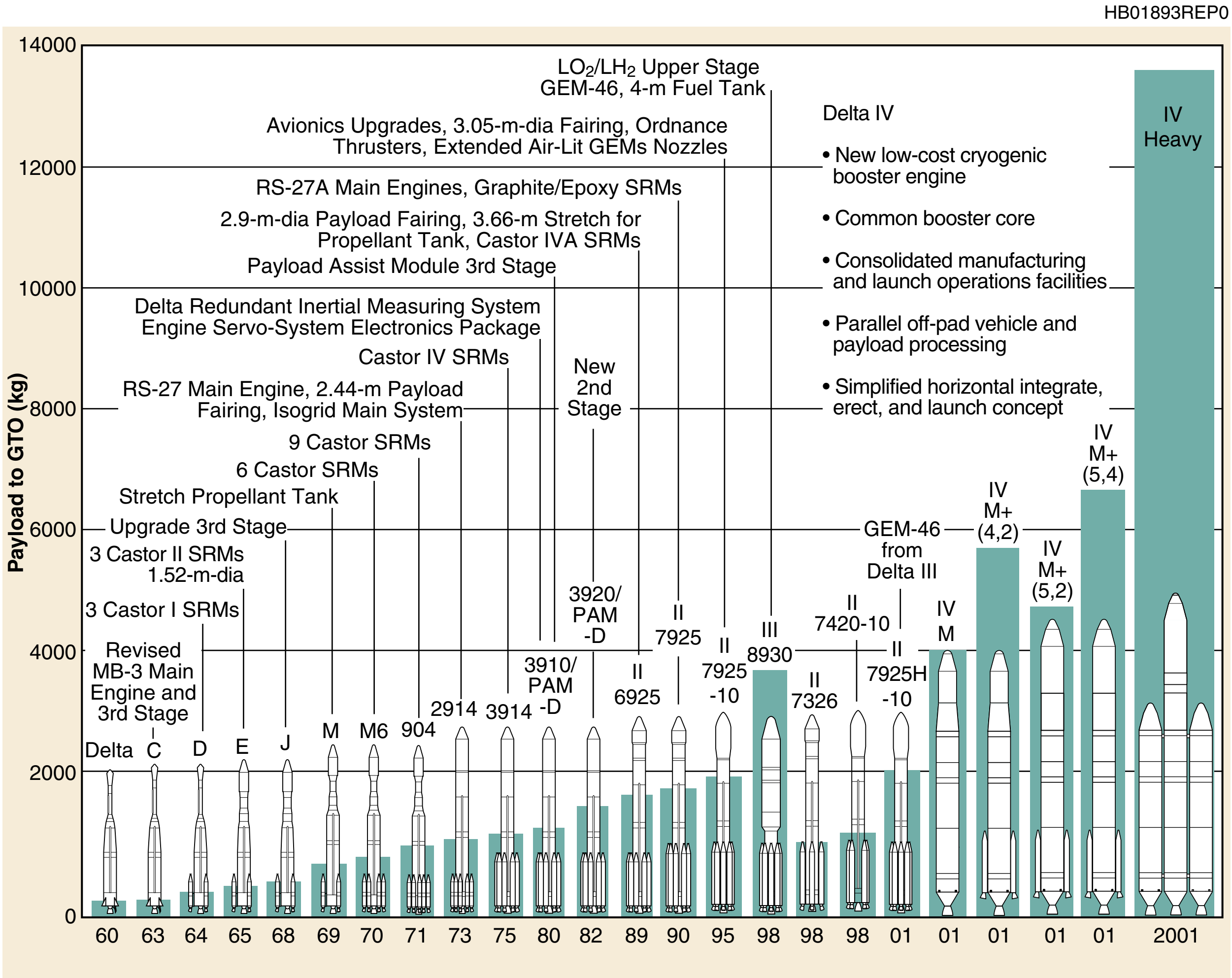


**Figure 1-1. Heritage of the Delta Family**

as Delta IV-M+ (4,2); the first digit in parentheses refers to the diameter of the second stage in meters, and the second digit refers to the number of strap-on SRMs. The other two configurations are the Delta IV-M+ (5,2) and M+ (5,4) that have two and four SRMs, respectively, to augment the first-stage CBC. Both of these configurations employ a 5-m (200-in.)-dia cryogenic second stage, and a 5-m (200-in.)-dia composite payload fairing.

■ The Delta IV-H employs two additional CBCs as strap-on liquid rocket boosters (LRBs) to augment the first-stage CBC, a cryogenic 5-m second stage, and either a 5-m composite fairing or a 5-m metallic fairing.

The Delta IV launch system is designed to place payloads into various orbits by launching from either the Eastern Range (ER) at Cape Canaveral Air Force Station (CCAFS), Florida, or the Western Range (WR) at Vandenberg Air Force Base (VAFB), California, whichever is appropriate for mission requirements. Each mission will be allocated to a specific Delta IV launch vehicle to support the required launch date, performance, delivery-to-orbit, and overall mission requirements.

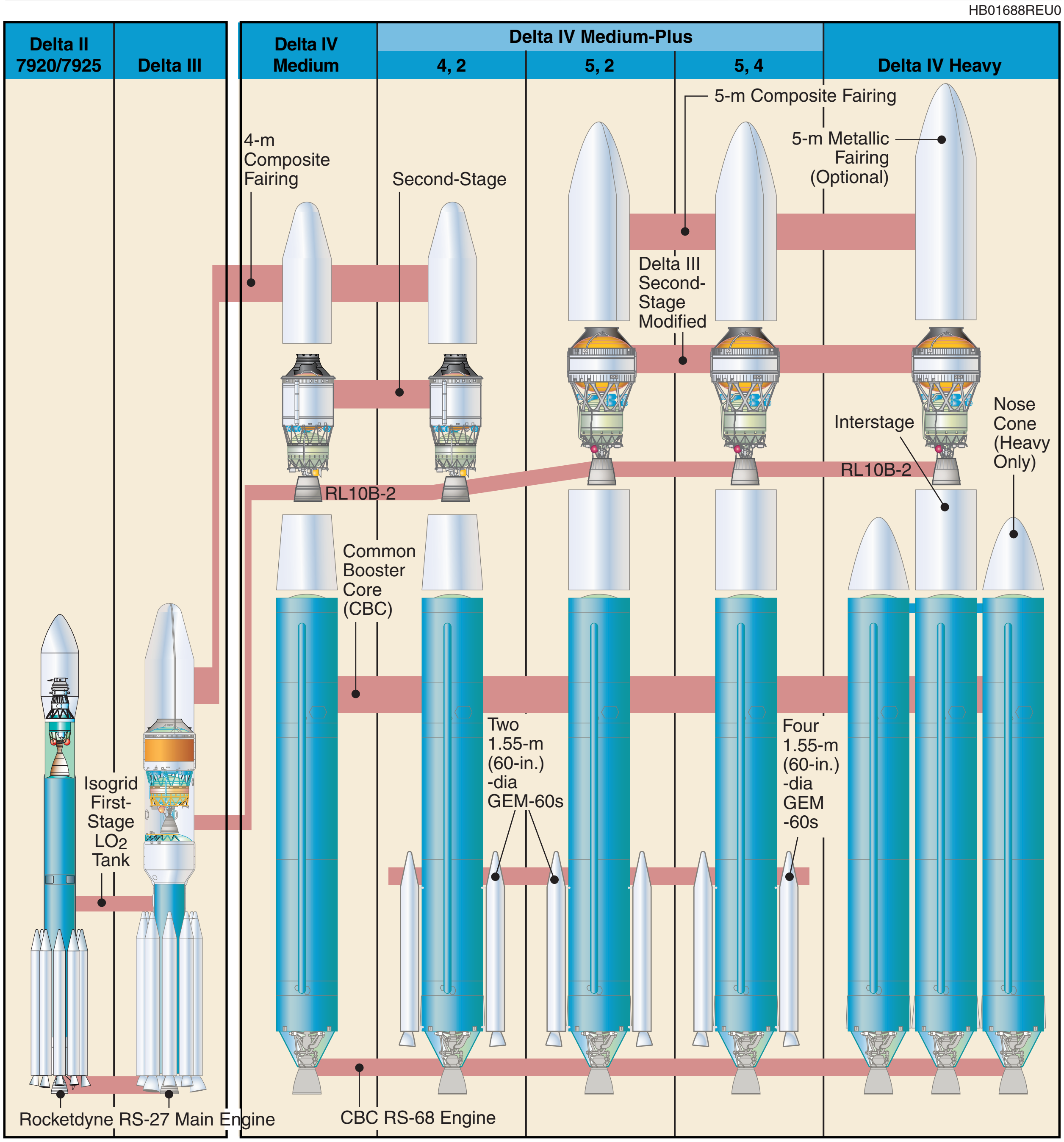


**Figure 1-2. Delta Launch Vehicle Family**

### 1.2.1 First Stage

The first-stage CBC (Figure 1-3) consists of the RS-68 engine, liquid hydrogen ($LH_2$) tank, center-body, liquid oxygen ($LO_2$) tank, and interstage.

The first stage CBC is powered by the new Rocketdyne RS-68 engine (Figure 1-4), a state-of-the-art, low-cost engine burning $LO_2$ and $LH_2$ cryogens, that is capable of delivering 2891 kN (650,000 lb) of thrust and having a specific impluse of 410 sec. The RS-68 can throttle down to 60% of full thrust level in a simple, single-step throttle profile designed to enhance reliability. It features proven technologies

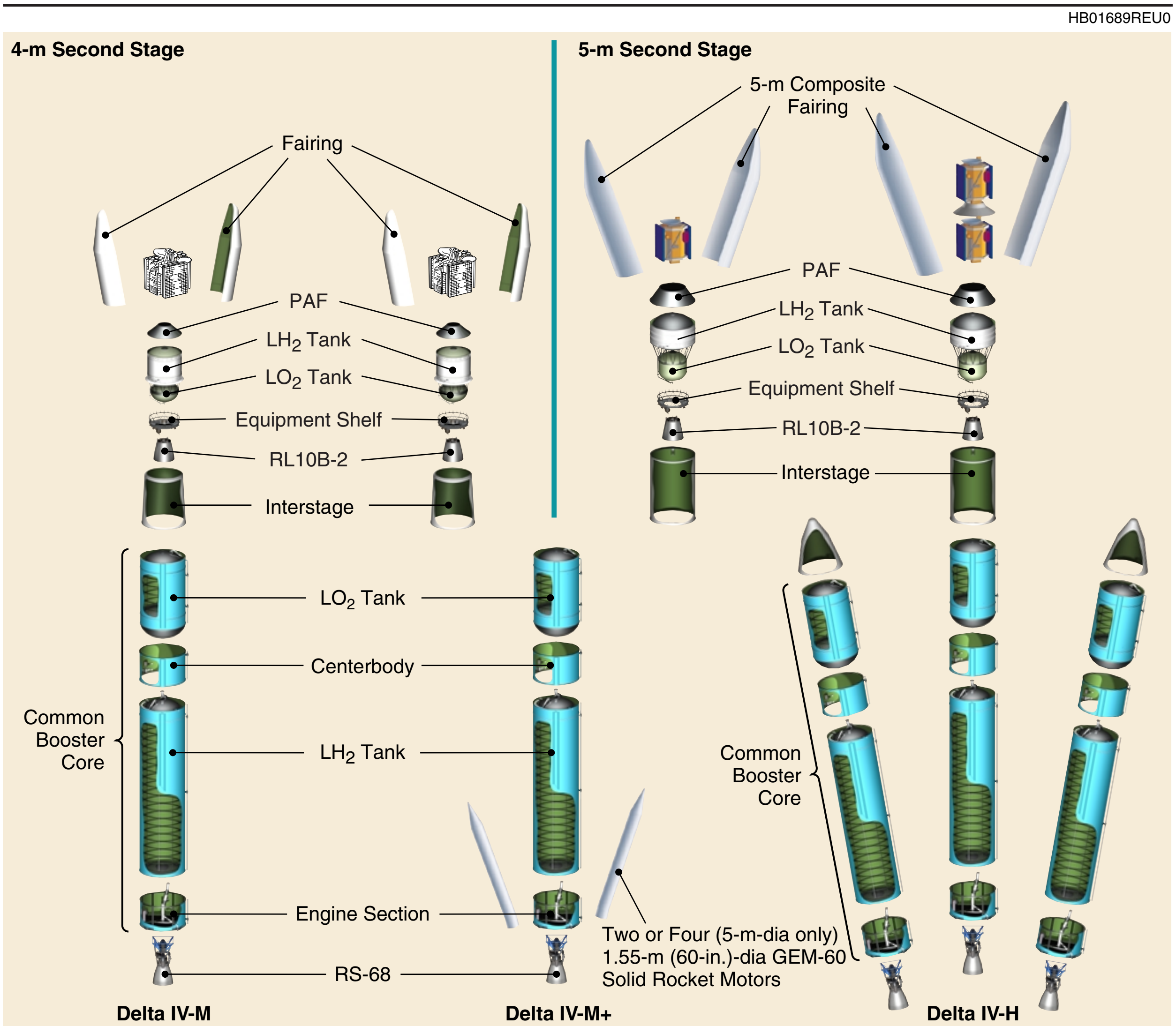


**Figure 1-3. Delta IV Launch Vehicle Description**

with the use of standard materials and minimum part count. The coaxial injector is derived from the Space Shuttle main engine (SSME) and uses low-cost materials and advanced fabrication techniques. The thrust chamber is an innovative hot isostatic press (HIP)-bonded evolution of the SSME design. The engine has a 21.5 to 1 expansion ratio and employs a gas generator, two turbopumps, and a regeneratively cooled thrust chamber. The thrust chamber and nozzle are hydraulically gimbaled to provide pitch and yaw control. Roll control for single-CBC vehicles is provided during main engine burn by vectoring the RS-68 turbine exhaust gases. Roll control for the Heavy vehicle is provided by gimbaling the RS-68 engines of the two strap-on LRBs.

The Delta IV-M+ configurations use either two or four 1.55-m (60-in.)-dia SRMs manufactured by Alliant Techsystems and designated as graphite-epoxy motors (GEM-60). These motors are derived from the smaller GEM-46 used on Delta III. Ordnance for

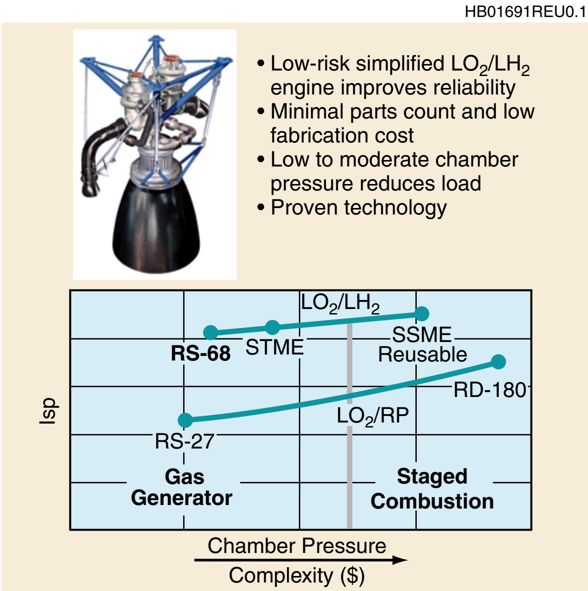


Figure 1-4. RS-68 Engine

motor ignition and separation systems is completely redundant. Separation is accomplished by initiating ordnance thrusters that provide a radial thrust to jettison the expended SRMs away from the first stage. The Delta IV-H uses two strap-on liquid rocket boosters (LRBs) with nose cones and separation motors.

The CBC has an overall dia of 5 m, so the interstage is tapered down to 4-m (157.5-in.) dia for the Delta IV-M and M+ (4,2) configurations that use a 4-m cryogenic second stage. The interstages for the Delta IV-M+ (5,2), M+ (5,4), and Heavy configurations have a 5-m-dia cylinder. For aerodynamic purposes, the liquid strap-on CBCs for the Delta IV-H employ nose cones in place of the interstage.

### 1.2.2 Second Stage

Two second-stage configurations (Figure 1-5) are offered on Delta IV: a 4-m version used on the Delta IV-M and Delta IV-M+ (4,2) and a 5-m version used on the Delta IV-M+ (5,2), Delta IV-M+ (5,4), and Delta IV-H.

Both second stages use the Delta III cryogenic Pratt & Whitney RL10B-2 engine, derived from the 36-year heritage of the flight-proven RL10 family. With an extendible nozzle, this engine produces a thrust of 110 kN (24,750 lb) and has a specific impluse of 462 sec. The engine gimbal system uses electromechanical actuators that provide high reliability while reducing both cost and weight. The RL10B-2 propulsion system and attitude control system (ACS) use flight-proven off-the-shelf components. The 4-m second stage is modified from that of Delta III with the total propellant load increased to 20 410 kg (45,000 lb), providing a total burn time of approximately 850 sec.

The 5-m second stage is based on the 4-m version. The $LO_2$ tank is lengthened by approximately 0.5 m, while the $LH_2$ tank's diameter is enlarged to 5 m. The total propellant load increases to 27 200 kg (60,000 lb), allowing a burn time of over 1125 sec.

Propellants are managed during coast by directing hydrogen boil-off through aft-facing thrusters to provide settling thrust, and by the use of the attitude control system (ACS), as required. Propellant tank pressurization during burn is accomplished using hydrogen bleed from the engine for the $LH_2$ tank and helium for the $LO_2$ tank. Missions with more than one restart (up to two) are accommodated by adding an extra helium bottle to the second stage for additional tank repressurization. The mission duration is 2.3 hr nominally, but may be increased to over 7 hr by

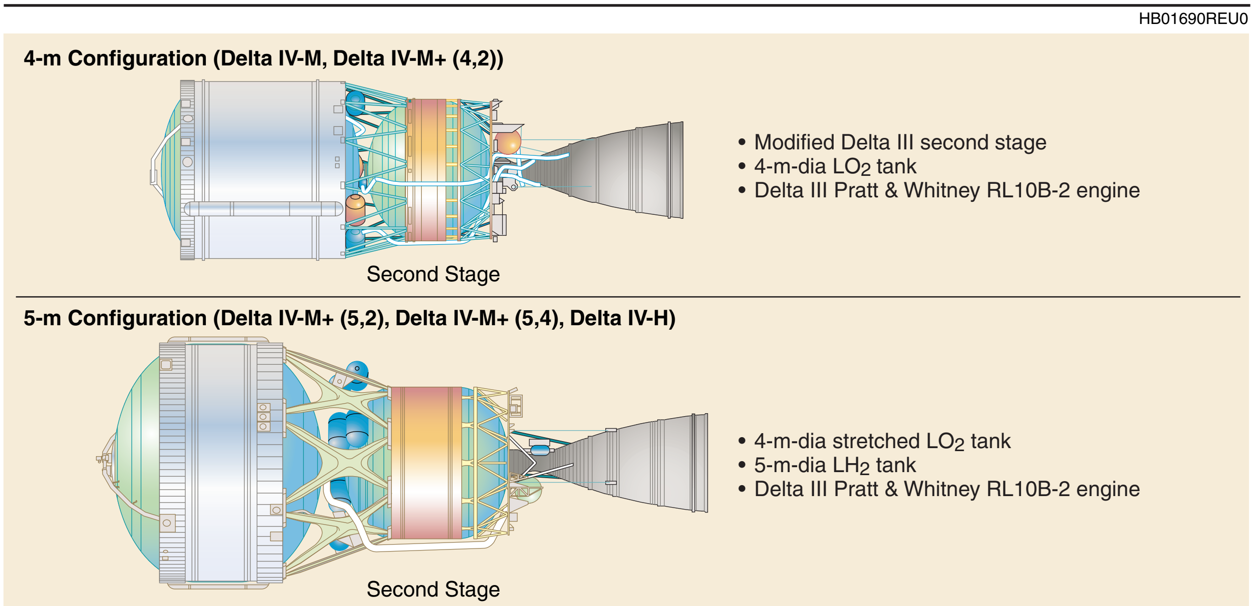


**Figure 1-5. Delta IV Second-Stage Configurations**

adding hydrazine bottles and batteries on the second stage. After payload separation, a contamination and collision avoidance maneuver (CCAM) is conducted to ensure adequate distance from the payload orbit prior to safing the stage.

### 1.2.3 Third Stage

Boeing is evaluating the use of a third stage for the Delta IV M+ and Delta IV-H launch vehicles for interplanetary missions. The third-stage design would be based on the proven Delta II design.

The heritage Delta II third stage consists of a Star 48B solid rocket motor, a payload attach fitting (PAF) with nutation control system (NCS), and a spin table containing small rockets for spin-up of the third stage/spacecraft. The Star 48B SRM has been flown on numerous missions and was developed from a family of high-performance apogee and perigee kick motors made by Thiokol Corporation. The flight-proven NCS, using monopropellant hydrazine prepressurized with helium, maintains orientation of the spin-axis of the third-stage/spacecraft stack during flight until spacecraft separation. This simple system has inherent reliability, with only one moving component and a leak-free design. Additional information about the heritage third-stage design is available in the Delta II Payload Planners Guide. Because the third-stage configuration is not currently baselined in the Delta IV program, no other reference to the third stage is made in this Payload Planners Guide at this time. For more information regarding use of a third stage, please contact Delta Launch Services.

### 1.2.4 Payload Attach Fittings (PAF)

The PAF provides the mechanical interface between the payload and the launch vehicle. The Delta IV launch system offers a selection of standard and modifiable PAFs to accommodate a variety of payload requirements. The customer has the option to provide the payload separation system and mate directly to a PAF provided by Boeing; or Boeing can supply the entire separation system. Payload separation systems typically incorporated on the PAF include clampband systems or explosive attach-bolt systems. The PAFs, with associated separation systems, are discussed in greater detail in Section 5.

Boeing has extensive experience designing and building satellite dispensing systems for multiple satellite launches. Our dispensers have a 100% success rate. For more information regarding satellite dispensing systems, please contact Delta Launch Services.

### 1.2.5 Payload Fairings (PLF)

The fairings protect the payload once the payload is encapsulated through boost flight. The Delta IV launch system offers PLFs (Figure 1-6) for different launch vehicle configurations.

The 4-m fairing is a stretched Delta III 4-m composite bisector design. The 5-m composite fairing for single-manifest missions is also based on that of Delta III and comes in two standard lengths: 14.3 m (47 ft) and 19.1 m (62.7 ft). The dual-manifest fairing consists of two sections—a 5-m composite bisector fairing and a lower 5-m composite dual-payload canister (DPC), and is available in two lengths: 19.1 m (62.7 ft) and 22.4 m (73.5 ft).

The 5-m metallic trisector fairing (the baseline for government programs) is a modified version of the flight-proven Titan IV aluminum isogrid fairing designed and manufactured by Boeing.

All PLFs are configured for off-pad payload encapsulation (Sections 6.3 and 7.3) to enhance payload safety and security, and to minimize on-pad time. Interior acoustic blankets as well as flight-proven contamination-free separation joints are incorporated into the fairing design for payload protection. Mission-specific fairing modifications can be made as required by the customer. These include access doors, additional acoustic blankets, and radio frequency (RF) windows. Payload fairings are discussed in more detail in Section 3.

### 1.2.6 Dual-Manifest Capability

The Delta IV launch system offers dual-manifest capability utilizing the Heavy configuration. This dual-manifest system provides payload autonomy similar to a dedicated launch, but at a significant cost reduction compared to a dedicated launch. The dual-manifest approach has the capability of launching two spacecraft totaling up to 10 700 kg (23 700 lb) to a standard 27-deg GTO orbit using a 5-m composite fairing that is 22.4 m (73.5 ft) long.

The 5-m-dia by 19.1-m (62.7-ft)-long dual-manifest system consists of a 12.3-m (40.3-ft)-long composite fairing and a 6.8-m (22.4-ft)-long DPC. The 5-m-dia by 22.4-m (73.5-ft)-long dual-manifest system consists of a 14.3-m (47-ft)-long composite bisector fairing and an 8.1-m (26.5-ft)-long DPC. Using standard PAFs, both payloads are mounted within two independent payload bays that are similar in volume and vented separately. Separate fairing

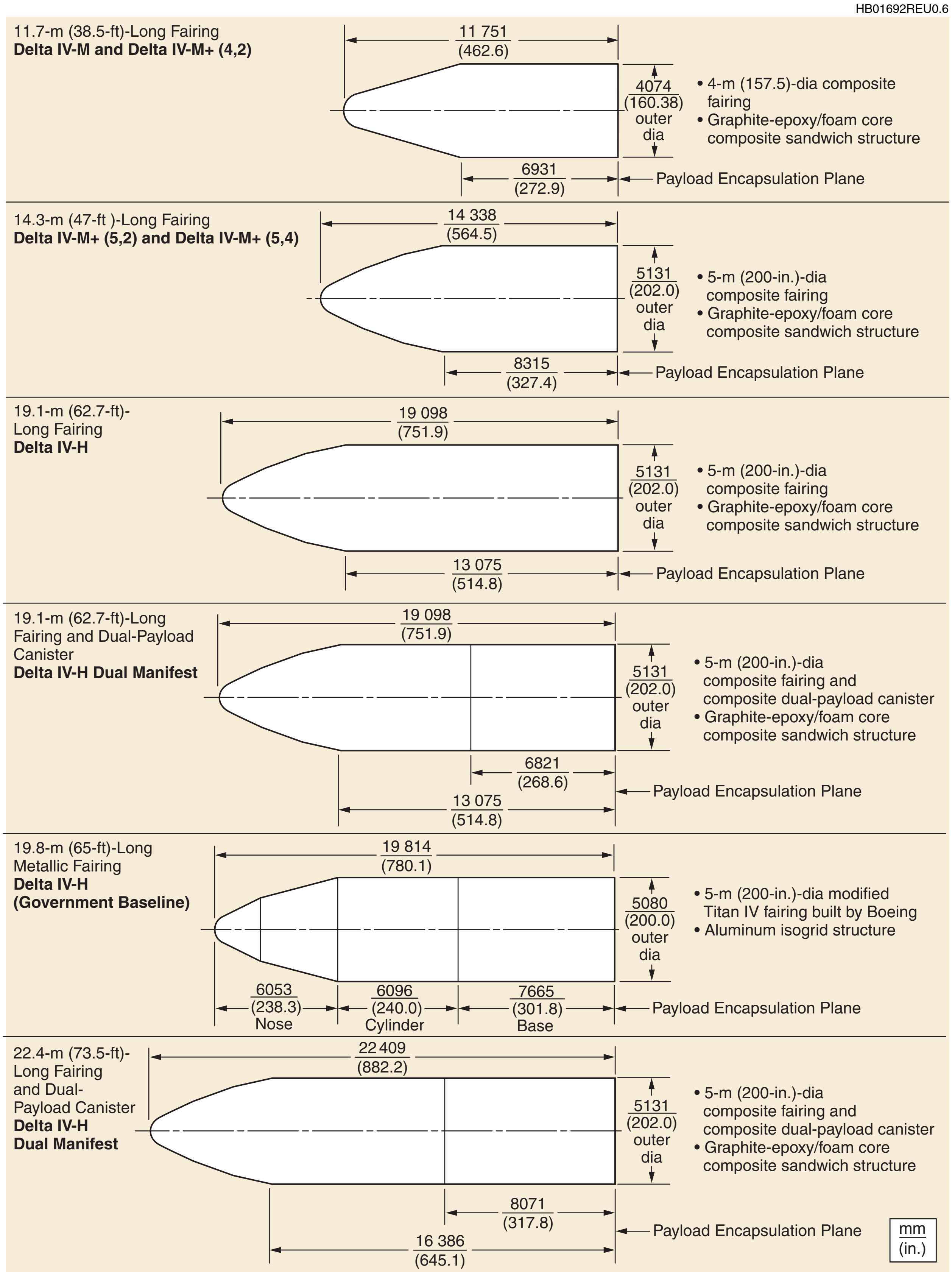


**Figure 1-6. Delta IV Fairing Configurations**

access doors of standard size are provided in the cylindrical section of each payload bay. As with the single-manifest mission, existing acoustic blankets are provided from the aft end of the fairing to the nose cone.

A contamination-free separation system that runs along the full length of the fairing is detonated to separate the fairing into halves, exposing the upper payload. For the lower bay, a circumferential Sure-Sep system (patented by Boeing) with spring actuators is used to deploy the DPC over the payload.

For dual-manifest capability on other Delta IV vehicle configurations, please contact Delta Launch Services.

### 1.2.7 Avionics and Flight Software

The Delta IV launch system uses a modified Delta III avionics system with a fully fault-tolerant avionics suite, including a redundant inertial flight control assembly (RIFCA) and automated launch operations processing using an advanced launch control system.

The RIFCA, supplied by AlliedSignal, uses six RL20 ring laser gyros and six QA3000 accelerometers to provide redundant three-axis attitude and velocity data. In addition to RIFCA, both the first- and second-stage avionics include interface and control electronics to support vehicle control and sequencing, a power and control box to support power distribution, and an ordnance box to issue ordnance commands. A pulse code modulation (PCM) telemetry (T/M) system delivers real-time launch vehicle data directly to ground stations or relays through the tracking and data relay satellite system (TDRSS). If ground coverage is not available, instrumented aircraft or TDRSS may be available, in coordination with NASA, to provide flexibility with telemetry coverage.

The flight software comprises a standard flight program and a mission-constants database specifically designed to meet each customer's mission sequence requirements. Mission requirements are implemented by configuring the mission-constants database, which is designed to fly the mission trajectory and to separate the satellite at the proper attitude and time. The mission-constants database is validated during the hardware/software functional validation tests and the systems integration tests. The final software validation test is accomplished during a full-length simulated flight test at the launch site.

The RIFCA contains the control logic that processes rate and accelerometer data to form the proportional and discrete control output commands needed to drive the control actuators and hydrazine control thrusters.

Position and velocity data are explicitly computed to derive guidance steering commands. Early in flight, a load-relief mode turns the vehicle into the wind to reduce angle of attack, structural loads, and control effort. After dynamic pressure decay, the guidance system corrects trajectory dispersions caused by winds and vehicle performance variations, and directs the vehicle to the nominal end-of-stage orbit. Payload separation in the desired transfer orbit is accomplished by applying time adjustments to the nominal engine start/stop sequence, in addition to the required guidance steering commands.

## 1.3 DELTA IV VEHICLE COORDINATE SYSTEM

The vehicle axes are defined in Figure 1-7. An overhead view shows the vehicle orientation to the launch pad. The launch vehicle coordinate system is shown with the vehicle pitch, roll and yaw. The vehicle centerline is the longitudinal axis of the vehicle. Axis II (+Z) is on the downrange side of the vehicle, and axis IV (-Z) is on the up-range side. The vehicle pitches about axes I (+Y) and III (-Y). Positive pitch rotates the nose of the vehicle up, toward axis IV. The vehicle yaws about axes II and IV. Positive yaw rotates the nose to the right, toward axis I. The vehicle rolls about the

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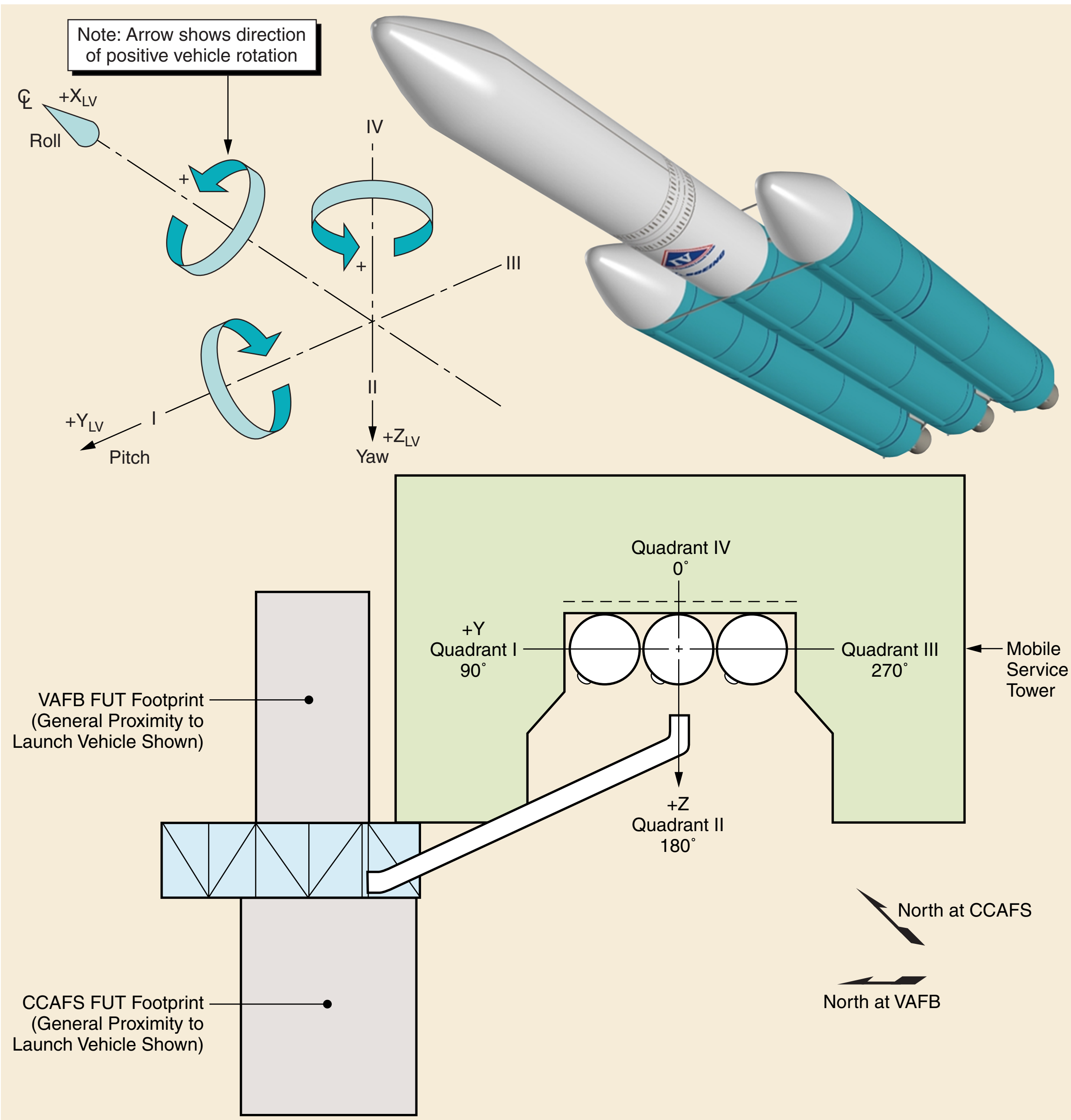


**Figure 1-7. Launch Vehicle Axes**

centerline. Positive roll is clockwise rotation, looking forward from the aft end of the vehicle (i.e., from axis I toward axis II).

### 1.3.1 Orientation

Two distinct coordinate systems are of interest to the spacecraft customer. The first is the launch vehicle coordinate system that has already been discussed. The second is the payload accommodations (PLA) coordinate system. Figure 1-8 shows the orientation of the payload accommodations coordinate system relative to the launch vehicle coordinate system. The PLA coordinate system is similar to the launch vehicle coordinate system but is clocked positive 33 deg from the launch vehicle coordinate system. In this Payload Planners Guide, all coordinates are in the launch vehicle coordinate system unless otherwise stated.

### 1.3.2 Station Number

Station number units are in inches and measured along the X-axis of the launch vehicle coordinate system. The origin of the launch vehicle coordinate system is near the top of the mobile service tower. Refer to Section 3 for launch vehicle station locations at the payload encapsulation plane.

## 1.4 LAUNCH VEHICLE INSIGNIA

Delta IV customers are invited to create a mission-specific insignia to be placed on their launch vehicles. The customer is invited to submit the proposed design no later than nine months prior to launch for review and approval. The maximum size of the insignia is 4.7 m by 4.7 m (15 ft by 15 ft). Following approval, the flight insignia will be prepared and placed on the up-range side of the launch vehicle.

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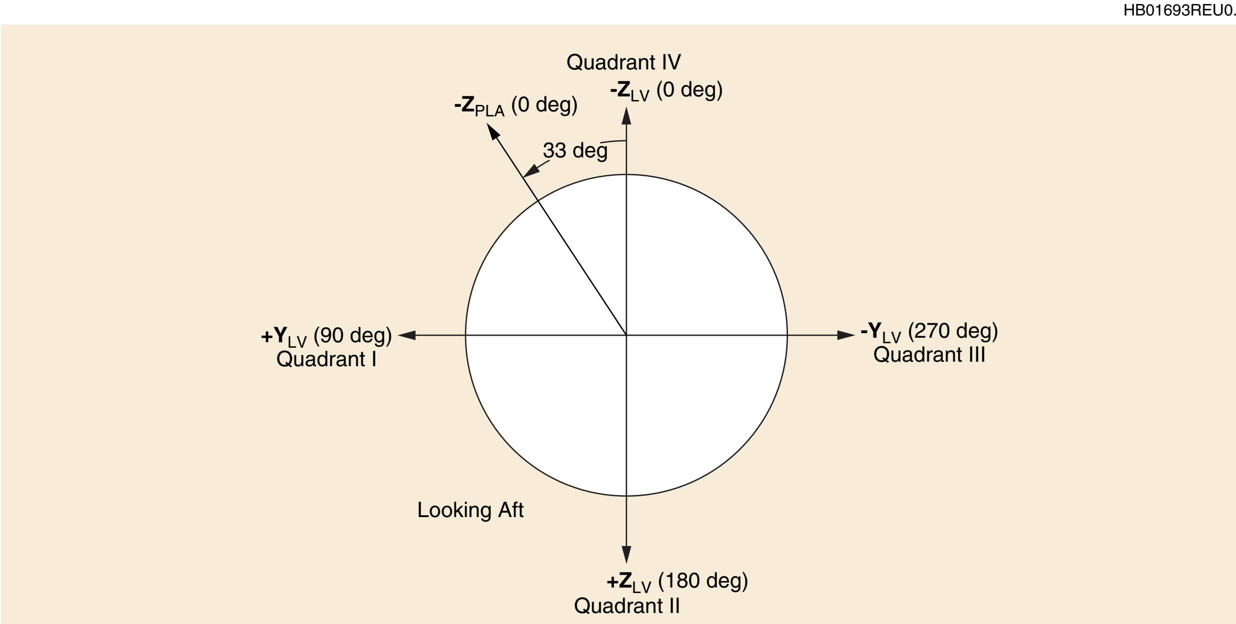


**Figure 1-8. Launch Vehicle vs. Payload Accommodations Coordinate System**

# Section 2
# GENERAL PERFORMANCE CAPABILITY

The Delta IV launch system can accommodate a wide variety of mission requirements from both the Eastern and Western launch ranges. The following sections are presented to describe the Delta IV launch vehicle performance for planning purposes. Individual mission requirements and specifications will be used to perform detailed performance analyses for specific customer missions. Boeing mission designers can provide innovative performance trades to meet specific requirements. Our customers are encouraged to contact Delta Launch Services for further information.

## 2.1 LAUNCH SITES

Depending on the specific mission requirement and range safety restrictions, the Delta IV can be launched from either an East Coast or West Coast launch site.

### 2.1.1 East Coast Launch Site

The Delta IV eastern launch site is Space Launch Complex 37 (SLC-37) at Cape Canaveral Air Force Station (CCAFS), Florida. This site can accommodate flight azimuths in the range of 42 deg to 110 deg, with 95 deg being the most commonly flown.

### 2.1.2 West Coast Launch Site

The western launch site for Delta IV is Space Launch Complex 6 (SLC-6) at Vandenberg Air Force Base (VAFB), California. This site can accommodate flight azimuths in the range of 151 deg to 210 deg.

## 2.2 MISSION PROFILES

Delta IV mission profiles are derived from our long history of reliable Delta II trajectories and sequences of events. Our highly accurate redundant inertial flight control assembly (RIFCA) inserts payloads into orbits with significantly better-than-specified accuracy (Section 2.4), increasing spacecraft lifetimes. C-band coverage for range safety is provided by ground stations until safe orbit is achieved and the command-destruct receivers are turned off. After first/second-stage separation, the telemetry is switched to the NASA tracking and data relay satellite system (TDRSS). Payload fairing jettison and payload separation events will be tailored during the mission integration process to satisfy mission requirements. A typical two-stage mission profile is shown in Figure 2-1.

After separation of the spacecraft, with launch vehicle attitude control thrusters deactivated, a coast period is allowed to provide the required launch-vehicle-to-spacecraft separation distance prior to reactivating the control thrusters. Following the coast period, a contamination and collision avoidance maneuver (CCAM) is performed to remove the second stage from the spacecraft's orbit,

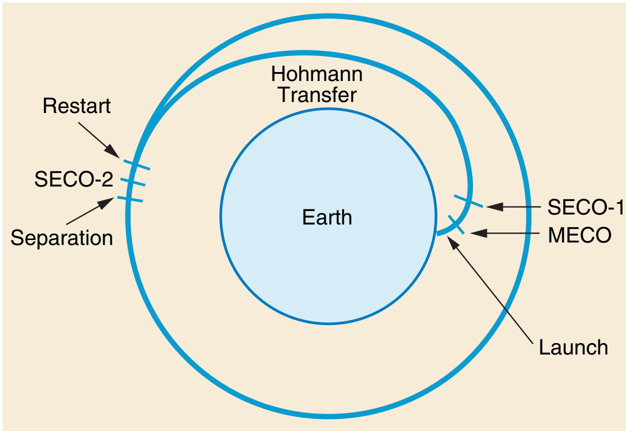


**Figure 2-1. Typical Two-Stage Mission Profile**

followed by vehicle safing (burning or venting of propellants). Preliminary and final nominal mission three-degrees-of-freedom (3-DOF) trajectories will simulate the distance and attitude time histories of the launch vehicle from separation through end of mission, including CCAM, orbit disposal, and launch vehicle safing. Spacecraft separation clearance will be verified using 6-DOF simulation, as required. Six-DOF simulations will be used to verify that the control system can adequately perform the required attitude maneuvers and to determine the duty cycle of the control thrusters, which will be input to the contamination analysis. Closed-loop guided 3-DOF simulations will verify that the guidance can steer the launch vehicle and perform Delta IV maneuvers properly. For payloads requiring spin up prior to separation (Delta IV can achieve spin rates up to 5 rpm), 6-DOF simulations will be used to verify control system adequacy and spacecraft clearance during spinup, separation, launch vehicle coast, and despin. Our experience, capability, and accuracy assure that all customer requirements are met to ensure mission success.

### 2.2.1 GTO Mission Profile

The typical sequence of events for the Delta IV family of launch vehicles to a geosynchronous transfer orbit (GTO) of 185 km by 35 786 km (100 nmi by 19,323 nmi) at 27.0 deg inclination is shown in Figures 2-2, 2-3, and 2-4. The profile follows a sequence similar to the Delta II and Delta III trajectories to maximize payload lift capability. Injection into GTO may occur on either the descending or ascending node to accommodate spacecraft needs.

Following insertion into GTO, the second stage reorients to the correct three-axis attitude for spacecraft deployment, using the attitude control system's hydrazine thrusters. Our second stage is capable of any desired orientation required for spacecraft deployment. Spacecraft may also be spun up prior to separation for spin stabilization or thermal management. Separation immediately follows the required maneuvering. The mission operation time is less than 2.3 hr nominally, but may be increased to over 7 hr with added hydrazine bottles and batteries on the second stage.

### 2.2.2 LEO Mission Profile

The typical sequence of events for the Delta IV to low-Earth orbit (LEO) is summarized in Figures 2-5 and 2-6. The profile follows a sequence similar to the GTO trajectories, using a gravity turn followed by several pitch rates to arrive at the target orbits while maximizing payload lift capability. The second stage is capable of deploying multiple spacecraft simultaneously or singly, with reorientation and hold periods between each separation event (see

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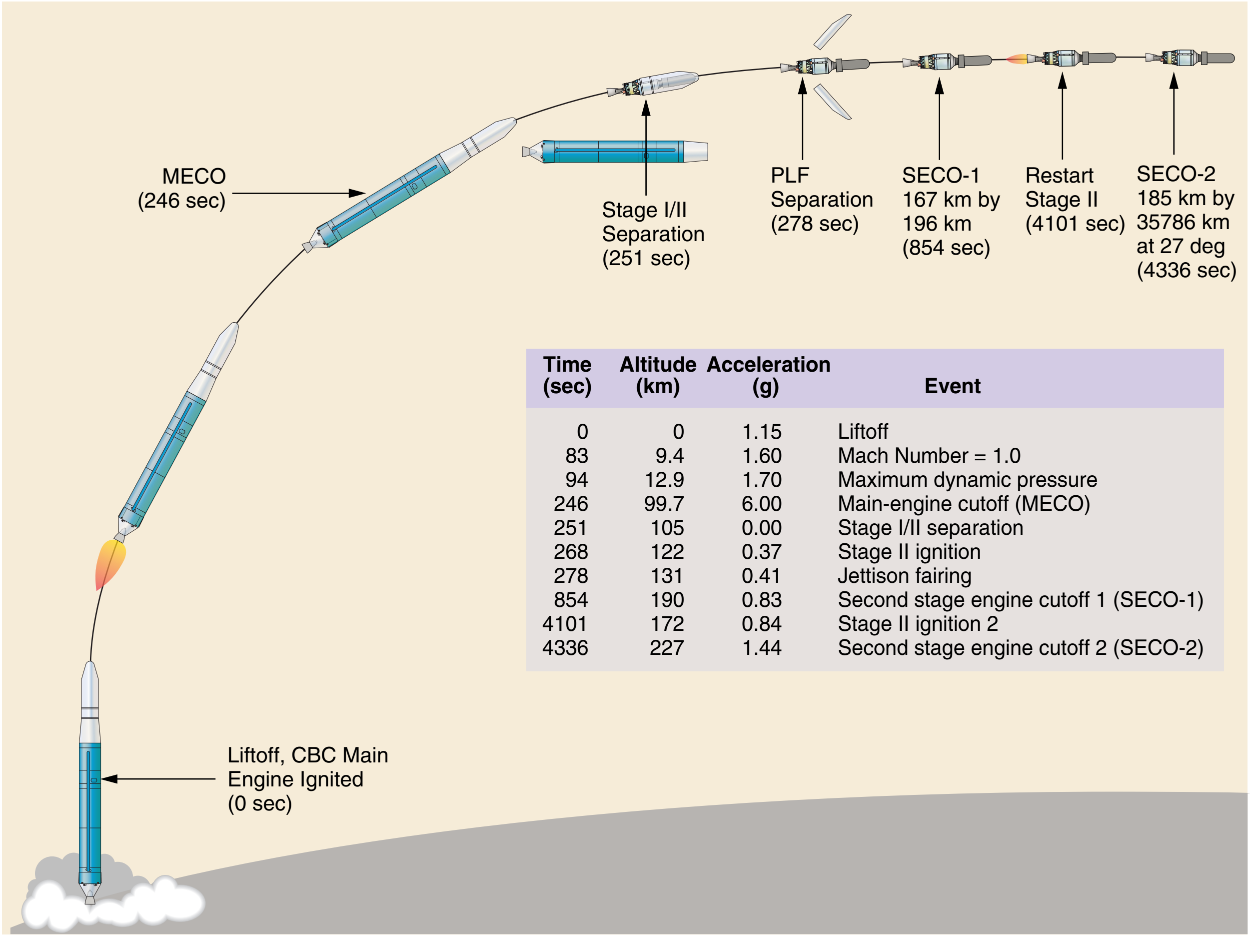


| Time (sec) | Altitude (km) | Acceleration (g) | Event |
|---|---|---|---|
| 0 | 0 | 1.15 | Liftoff |
| 83 | 9.4 | 1.60 | Mach Number = 1.0 |
| 94 | 12.9 | 1.70 | Maximum dynamic pressure |
| 246 | 99.7 | 6.00 | Main-engine cutoff (MECO) |
| 251 | 105 | 0.00 | Stage I/II separation |
| 268 | 122 | 0.37 | Stage II ignition |
| 278 | 131 | 0.41 | Jettison fairing |
| 854 | 190 | 0.83 | Second stage engine cutoff 1 (SECO-1) |
| 4101 | 172 | 0.84 | Stage II ignition 2 |
| 4336 | 227 | 1.44 | Second stage engine cutoff 2 (SECO-2) |

**Figure 2-2. Delta IV Medium Sequence of Events for a GTO Mission (Eastern Range)**

Section 2.2.5). The mission operation time is less than 2.3 hr nominally, but may be increased to over 7 hr with added hydrazine bottles and batteries on the second stage.

### 2.2.3 GEO Mission Profile

The Delta IV family is also capable of directly injecting the spacecraft into a geosynchronous Earth orbit (GEO) (Figure 2-7). Through the addition of a GEO-unique kit, the Delta IV-M+ (5,4), and Delta IV-H can carry the spacecraft directly to its desired GEO orbit or anywhere in between. Maximum mission operation time is 7.2 hr.

### 2.2.4 Delta IV Heavy Dual-Manifest GTO Mission Profile

The baseline dual-manifesting approach allows the customers to launch two payloads into GTO on a single Delta IV-H vehicle, at significant cost savings over two separate launches. The sequence of events through second stage engine cutoff 2 (SECO-2) for the dual-manifest Delta IV-H is shown in Figure 2-4. This places the second stage and payloads into the desired orbit. Figure 2-8 shows the dual-manifest deployment sequence. During the second stage burn, fairing jettison occurs and reveals the upper spacecraft. Upon reaching the target orbit, upper

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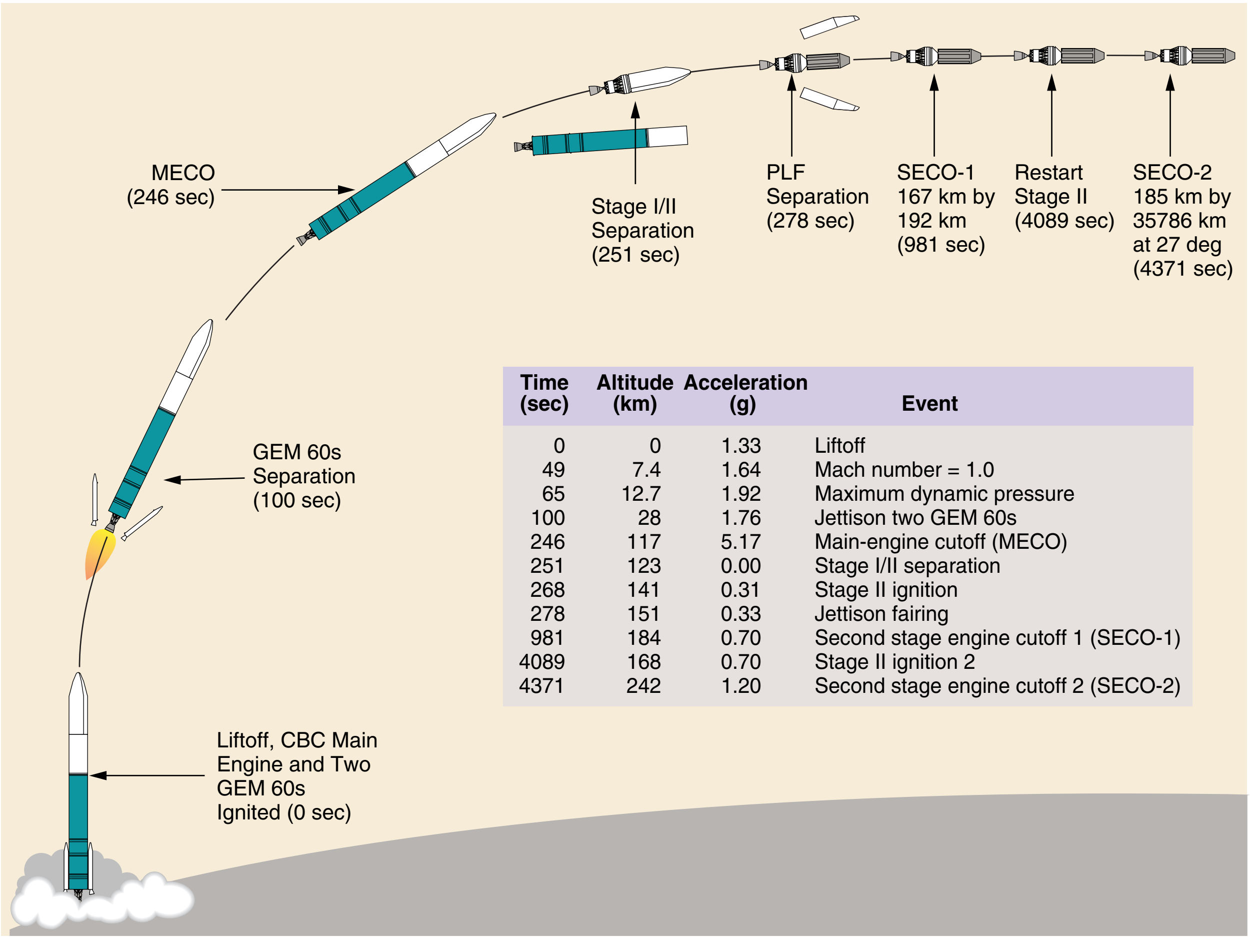


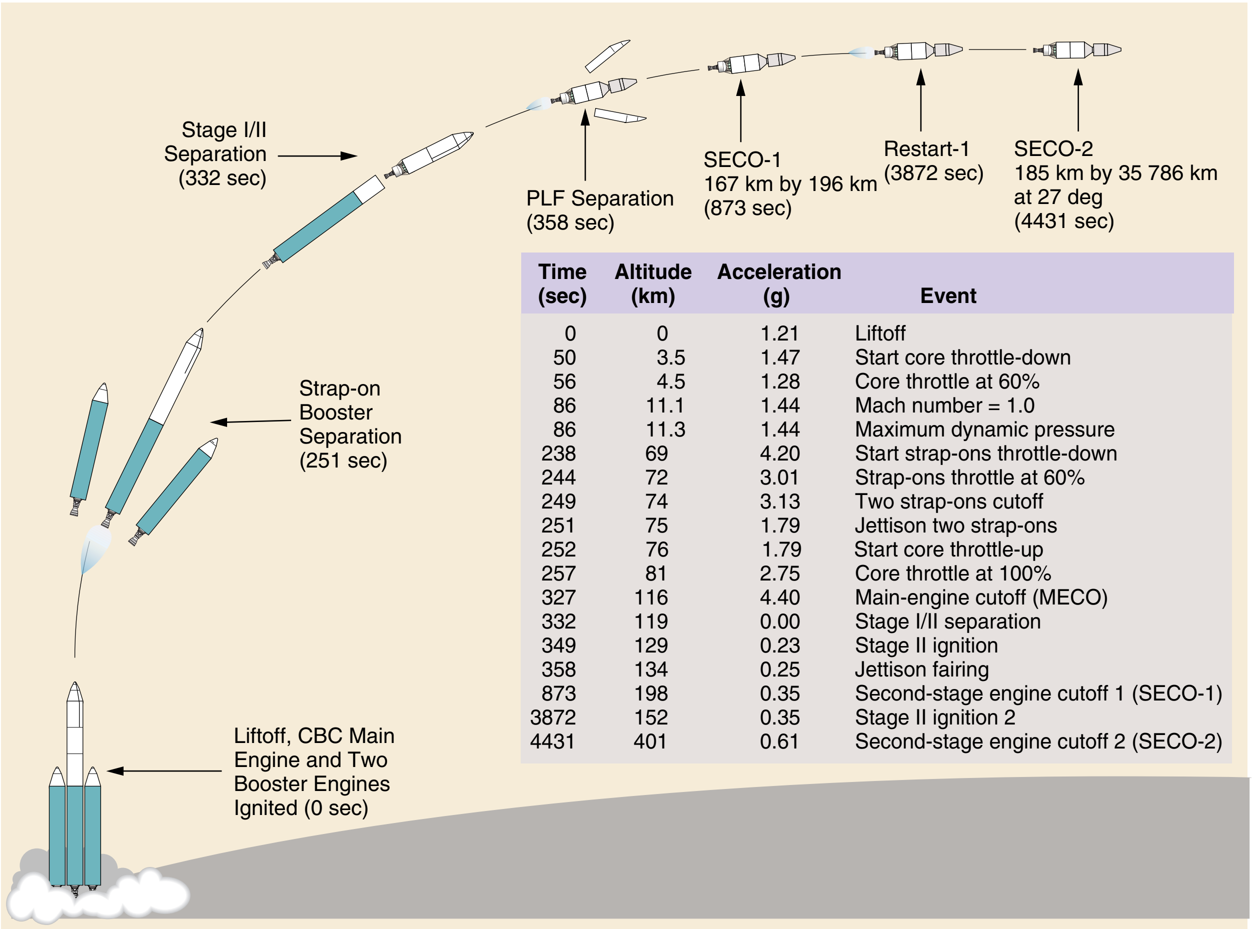

| Time (sec) | Altitude (km) | Acceleration (g) | Event |
|---|---|---|---|
| 0 | 0 | 1.33 | Liftoff |
| 49 | 7.4 | 1.64 | Mach number = 1.0 |
| 65 | 12.7 | 1.92 | Maximum dynamic pressure |
| 100 | 28 | 1.76 | Jettison two GEM 60s |
| 246 | 117 | 5.17 | Main-engine cutoff (MECO) |
| 251 | 123 | 0.00 | Stage I/II separation |
| 268 | 141 | 0.31 | Stage II ignition |
| 278 | 151 | 0.33 | Jettison fairing |
| 981 | 184 | 0.70 | Second stage engine cutoff 1 (SECO-1) |
| 4089 | 168 | 0.70 | Stage II ignition 2 |
| 4371 | 242 | 1.20 | Second stage engine cutoff 2 (SECO-2) |

**Figure 2-3. Delta IV Medium-Plus (5,2) Sequence of Events for a GTO Mission (Eastern Range)**

spacecraft deployment occurs. After the first payload reaches an acceptable distance from the launch vehicle, the second stage reorients to a new position. The combined upper payload attach fitting and dual-payload canister then separate from the second stage, revealing the lower spacecraft. Again, a reorientation maneuver is performed to achieve the target attitude of the lower spacecraft, then deployment occurs. The launch vehicle, which now consists of the second stage and lower payload attach fitting, reorients and performs the CCAM maneuver to remove itself from the spacecraft orbit. Boeing will coordinate with the customer to ensure that adequate separation distances are maintained through all separation events.

### 2.2.5 Multiple-Manifest Mission Profile

Boeing has extensive experience with multiple-manifest spacecraft and special on-orbit operations. Our experience with the deployment of multiple spacecraft has resulted in 100% successful deployment of the Iridium® and Globalstar™ spacecraft. We have successfully conducted missions involving rendezvous operations and multiple payloads flying in formation, both of which involve very precise orbits and tolerances. Our high level of experience with multiple-manifest missions and special on-orbit operations helps ensure complete mission success.



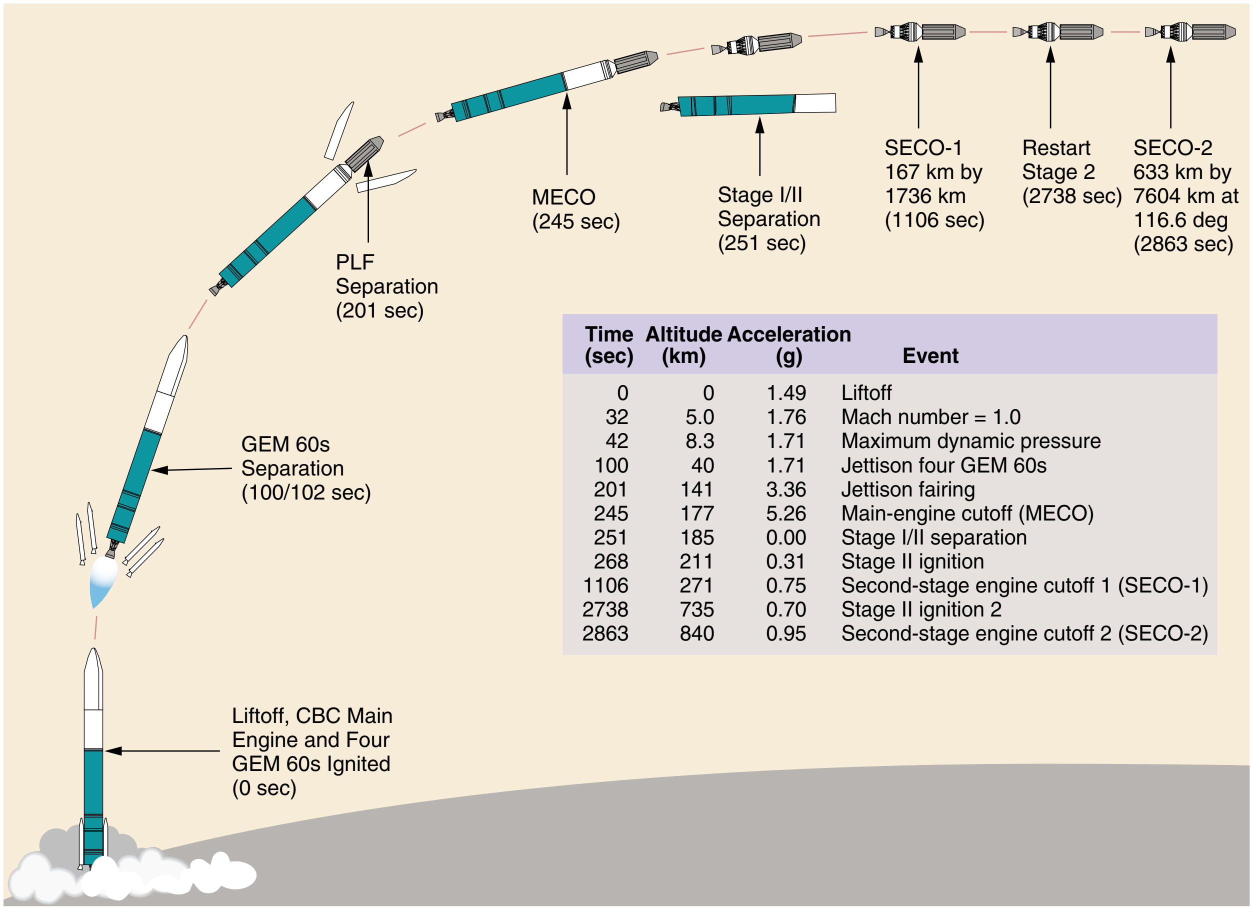

| Time (sec) | Altitude (km) | Acceleration (g) | Event |
|---|---|---|---|
| 0 | 0 | 1.21 | Liftoff |
| 50 | 3.5 | 1.47 | Start core throttle-down |
| 56 | 4.5 | 1.28 | Core throttle at 60% |
| 86 | 11.1 | 1.44 | Mach number = 1.0 |
| 86 | 11.3 | 1.44 | Maximum dynamic pressure |
| 238 | 69 | 4.20 | Start strap-ons throttle-down |
| 244 | 72 | 3.01 | Strap-ons throttle at 60% |
| 249 | 74 | 3.13 | Two strap-ons cutoff |
| 251 | 75 | 1.79 | Jettison two strap-ons |
| 252 | 76 | 1.79 | Start core throttle-up |
| 257 | 81 | 2.75 | Core throttle at 100% |
| 327 | 116 | 4.40 | Main-engine cutoff (MECO) |
| 332 | 119 | 0.00 | Stage I/II separation |
| 349 | 129 | 0.23 | Stage II ignition |
| 358 | 134 | 0.25 | Jettison fairing |
| 873 | 198 | 0.35 | Second-stage engine cutoff 1 (SECO-1) |
| 3872 | 152 | 0.35 | Stage II ignition 2 |
| 4431 | 401 | 0.61 | Second-stage engine cutoff 2 (SECO-2) |

**Figure 2-4. Delta IV Heavy Sequence of Events for a GTO Mission (Eastern Range)**

A typical sequence of events for a multiple-spacecraft mission would proceed as follows. After second-stage engine cutoff, the launch vehicle, which now consists of the second stage, dispenser, and spacecraft, is in the desired target orbit. The second stage reorients to the correct three-axis attitude for spacecraft deployment, using the attitude control system's hydrazine thrusters. Our second stage is capable of any desired orientation required for spacecraft deployment.

Following each deployment sequence, the launch vehicle waits to obtain sufficient separation distance between the launch vehicle and the spacecraft before initiating the next deployment sequence, or until ground coverage is available, if necessary. The launch vehicle can be reoriented to a different position, such as a relative position that follows the velocity vector, for the next deployment.

Alternating deployment and reorient/wait periods are repeated as necessary until all spacecraft are deployed. For simultaneous deployment of multiple spacecraft, the total time to deploy all spacecraft is not expected to exceed 1 hr. However, if the individual spacecraft are separated one




| Time (sec) | Altitude (km) | Acceleration (g) | Event |
|---|---|---|---|
| 0 | 0 | 1.49 | Liftoff |
| 32 | 5.0 | 1.76 | Mach number = 1.0 |
| 42 | 8.3 | 1.71 | Maximum dynamic pressure |
| 100 | 40 | 1.71 | Jettison four GEM 60s |
| 201 | 141 | 3.36 | Jettison fairing |
| 245 | 177 | 5.26 | Main-engine cutoff (MECO) |
| 251 | 185 | 0.00 | Stage I/II separation |
| 268 | 211 | 0.31 | Stage II ignition |
| 1106 | 271 | 0.75 | Second-stage engine cutoff 1 (SECO-1) |
| 2738 | 735 | 0.70 | Stage II ignition 2 |
| 2863 | 840 | 0.95 | Second-stage engine cutoff 2 (SECO-2) |

**Figure 2-5. Delta IV Medium-Plus (5,4) Sequence of Events for a LEO Mission (Western Range)**

at a time, more on-orbit time is needed. Our launch vehicle is nominally sized for total mission durations up to 2.3 hr, but may be increased with minor modifications.

## 2.3 ORBITAL ACCURACY

All Delta IV configurations employ the Delta II-proven redundant inertial flight control assembly (RIFCA) system. This system provides precise pointing and orbit accuracy. Our heritage of inserting payloads into orbits with significantly better-than-predicted accuracy is well demonstrated. While successful Delta missions have inserted payloads to better than the 3-σ orbit requirements, the achieved orbits of the ten most recent two-stage Delta II missions are presented in Table 2-1 as a sampling of the effectiveness of our highly accurate avionics system.

Table 2-2 summarizes currently predicted 3-σ orbit accuracy for the Delta IV family to typical LEO and GTO orbits. These data are presented as general indicators only. Individual mission requirements and specifications will be used to perform detailed analyses for specific missions. The customer is invited to contact Delta Launch Services for further information.

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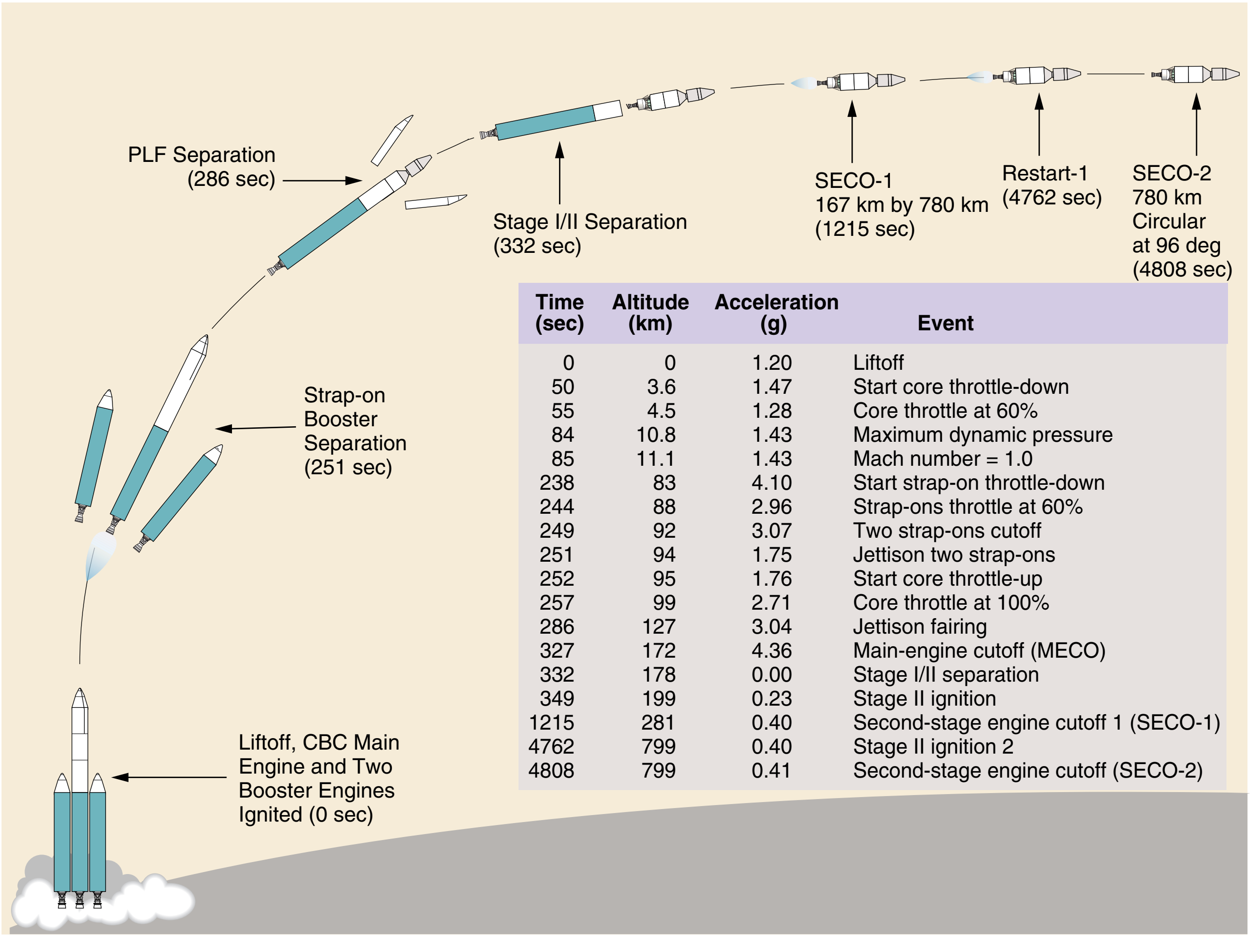


| Time (sec) | Altitude (km) | Acceleration (g) | Event |
|---|---|---|---|
| 0 | 0 | 1.20 | Liftoff |
| 50 | 3.6 | 1.47 | Start core throttle-down |
| 55 | 4.5 | 1.28 | Core throttle at 60% |
| 84 | 10.8 | 1.43 | Maximum dynamic pressure |
| 85 | 11.1 | 1.43 | Mach number = 1.0 |
| 238 | 83 | 4.10 | Start strap-on throttle-down |
| 244 | 88 | 2.96 | Strap-ons throttle at 60% |
| 249 | 92 | 3.07 | Two strap-ons cutoff |
| 251 | 94 | 1.75 | Jettison two strap-ons |
| 252 | 95 | 1.76 | Start core throttle-up |
| 257 | 99 | 2.71 | Core throttle at 100% |
| 286 | 127 | 3.04 | Jettison fairing |
| 327 | 172 | 4.36 | Main-engine cutoff (MECO) |
| 332 | 178 | 0.00 | Stage I/II separation |
| 349 | 199 | 0.23 | Stage II ignition |
| 1215 | 281 | 0.40 | Second-stage engine cutoff 1 (SECO-1) |
| 4762 | 799 | 0.40 | Stage II ignition 2 |
| 4808 | 799 | 0.41 | Second-stage engine cutoff (SECO-2) |

**Figure 2-6. Delta IV Heavy Sequence of Events for a LEO Mission (Western Range)**

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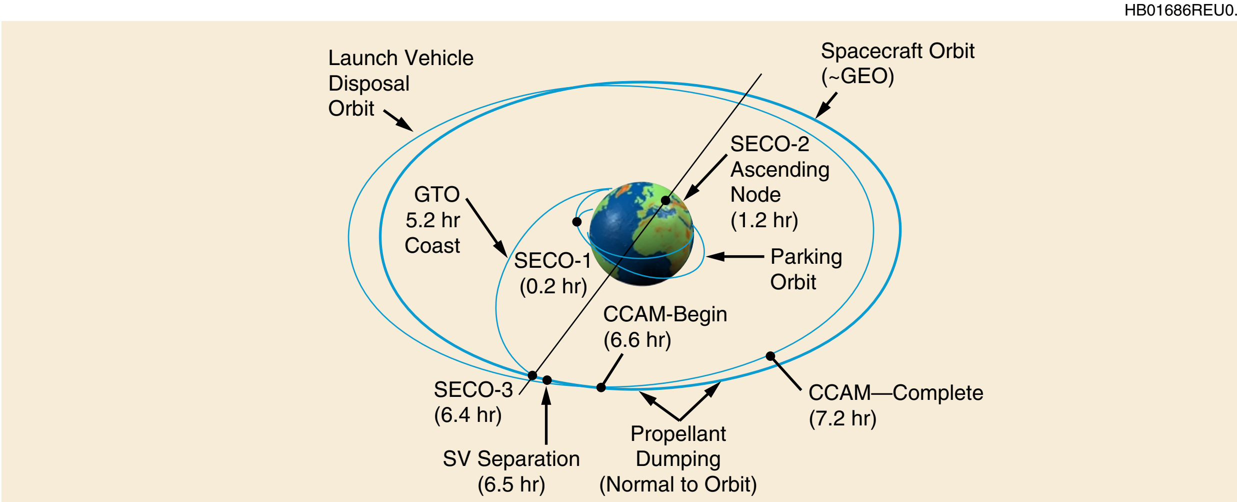


**Figure 2-7. Ascending Node GEO Mission Profile**

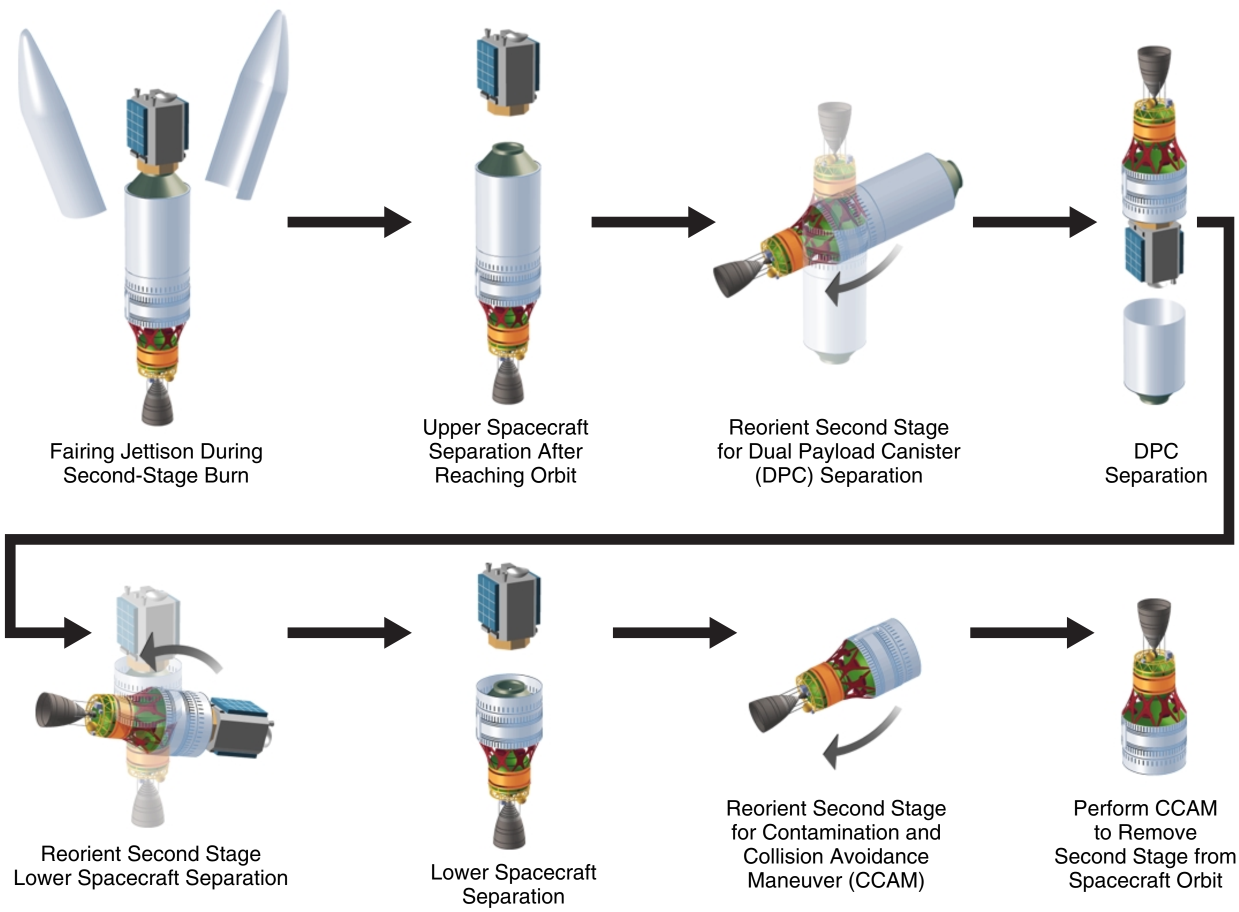


**Figure 2-8. Baseline Dual-Manifest Separation Sequence of Events**

**Table 2-1. RIFCA 3-σ Orbit Accuracy—Ten Recent Two-Stage Delta II Missions**

| | | Orbit dispersions | | | | | |
|---|---|---|---|---|---|---|---|
| | | Perigee altitude (nmi) | | Apogee altitude (nmi) | | Inclination (deg) | |
| Mission | Launch date | Predicted 3σ | Achieved | Predicted 3σ | Achieved | Predicted 3σ | Achieved |
| MS-9 | 17-May-98 | +0.5/-15.1 | -0.8 | +3.3/-0.5 | +2.2 | ±0.03 | +0.00 |
| MS-10 | 8-Sep-98 | +0.5/-15.1 | +0.0 | +3.3/-0.5 | +1.0 | ±0.03 | +0.01 |
| P91-1 | 23-Feb-99 | +2.0/-3.8 | +1.4 | +3.4/-2.0 | +1.8 | ±0.03 | +0.00 |
| Landsat-7 | 15-Apr-99 | +0.5/-11.8 | +0.0 | +3.0/-2.9 | +0.6 | ±0.03 | +0.00 |
| Globalstar-3 | 10-Jun-99 | +0.8/-19.6 | -0.3 | +4.5/-0.8 | +0.2 | ±0.03 | +0.00 |
| FUSE | 24-Jun-99 | +1.8/-6.2 | -0.6 | +3.7/-1.6 | +0.5 | +0.06/-0.01 | +0.00 |
| Globalstar-4 | 10-Jul-99 | +0.8/-19.6 | +0.1 | +4.5/-0.8 | +0.4 | ±0.03 | +0.00 |
| Globalstar-5 | 25-Jul-99 | +0.8/-19.6 | +0.1 | +4.5/-0.8 | +0.4 | ±0.03 | +0.00 |
| Globalstar-6 | 17-Aug-99 | +0.8/-19.6 | -0.4 | +4.5/-0.8 | +0.1 | ±0.03 | +0.01 |
| Globalstar-7 | 8-Feb-00 | +0.8/-19.6 | -0.1 | +4.5/-0.8 | +0.7 | ±0.03 | +0.00 |

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**Table 2-2. Predicted 3-σ Orbit Accuracies for the Delta IV Family of Launch Vehicles**

| Orbit | Parameter | 3-σ accuracy |
|---|---|---|
| **GTO** 185 km by 35 786 km at 27 deg (100 nmi by 19,323 nmi at 27 deg) Ascending node injection | Perigee altitude | ±5.6 km (±3.0 nmi) |
| | Apogee altitude | ±93 km (±50 nmi) |
| | Inclination | ±0.03 deg |
| **LEO** 500 km circular at 90 deg (270 nmi circular at 90 deg) | Perigee altitude | ±7.4 km (±4.0 nmi) |
| | Apogee altitude | ±7.4 km (±4.0 nmi) |
| | Inclination | ±0.04 deg |

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## 2.4 PERFORMANCE SUMMARIES

Performance data are presented in the following pages for the Delta IV launch vehicle family. Descriptions and figure numbers of the performance curves for both Eastern and Western Range launches are listed in Table 2-3. The performance estimates include the following assumptions:

- Nominal propulsion system models and weight models were used.
- Second-stage propellant reserve is sufficient to provide a 99.865% probability of command shutdown (PCS) by the guidance system.
- Payload fairing separation occurs at a time when the free-molecular heating rate is equal to or less than 1135 W/m$^2$ (0.1 Btu/ft$^2$-sec).

Orbit capability is presented as “Separated Spacecraft Weight” for near-synchronous orbits and as “Useful Load Weight” for LEO orbits. The “Separated Spacecraft Weight” is defined as the spacecraft weight above the standard Delta IV payload attach fitting (PAF) (PAF-1194-4 for 4-m second stages and PAF-1194-5 for 5-m second stages, which are close approximations for all PAF configurations). The “Useful Load Weight” is the total payload weight available to be distributed between the spacecraft and the PAF/dispenser (i.e., the PAF/dispenser weight is included as part of the payload weight, not as part of the Delta IV second-stage weight). Note that in Figures 2-33a, b, and 2-34, which present the Delta IV Heavy dual-manifest capability, the “Separated Spacecraft Weight” illustrated in the orbit capability curves represents the combined weight of both separated spacecraft.

For the “excess ΔV” figures, the “excess ΔV” is defined as the second-stage impulsive velocity (ΔV) capability remaining (excess) after achieving the initial parking orbit, that could be used to further change the orbit. Note that the “excess ΔV” is the impulsive velocity in excess of that required for the flight performance reserve.

**Table 2-3. Figure Numbers for the Delta IV Vehicle Performance Curves**

| Figure description | Delta IV Medium | Delta IV Medium-Plus (4,2) | (5,2) | (5,4) | Delta IV Heavy |
|---|---|---|---|---|---|
| GTO capability | 2-9a and b | 2-15a and b | 2-21a and b | 2-27a and b | 2-33a and b |
| GTO excess ΔV capability | 2-10 | 2-16 | 2-22 | 2-28 | 2-34 |
| LEO circular orbit capability—ER | 2-11 | 2-17 | 2-23 | 2-29 | 2-35 |
| LEO excess ΔV capability—ER | 2-12 | 2-18 | 2-24 | 2-30 | 2-36 |
| LEO circular orbit capability—WR | 2-13 | 2-19 | 2-25 | 2-31 | 2-37 |
| LEO excess ΔV capability—WR | 2-14 | 2-20 | 2-26 | 2-32 | 2-38 |

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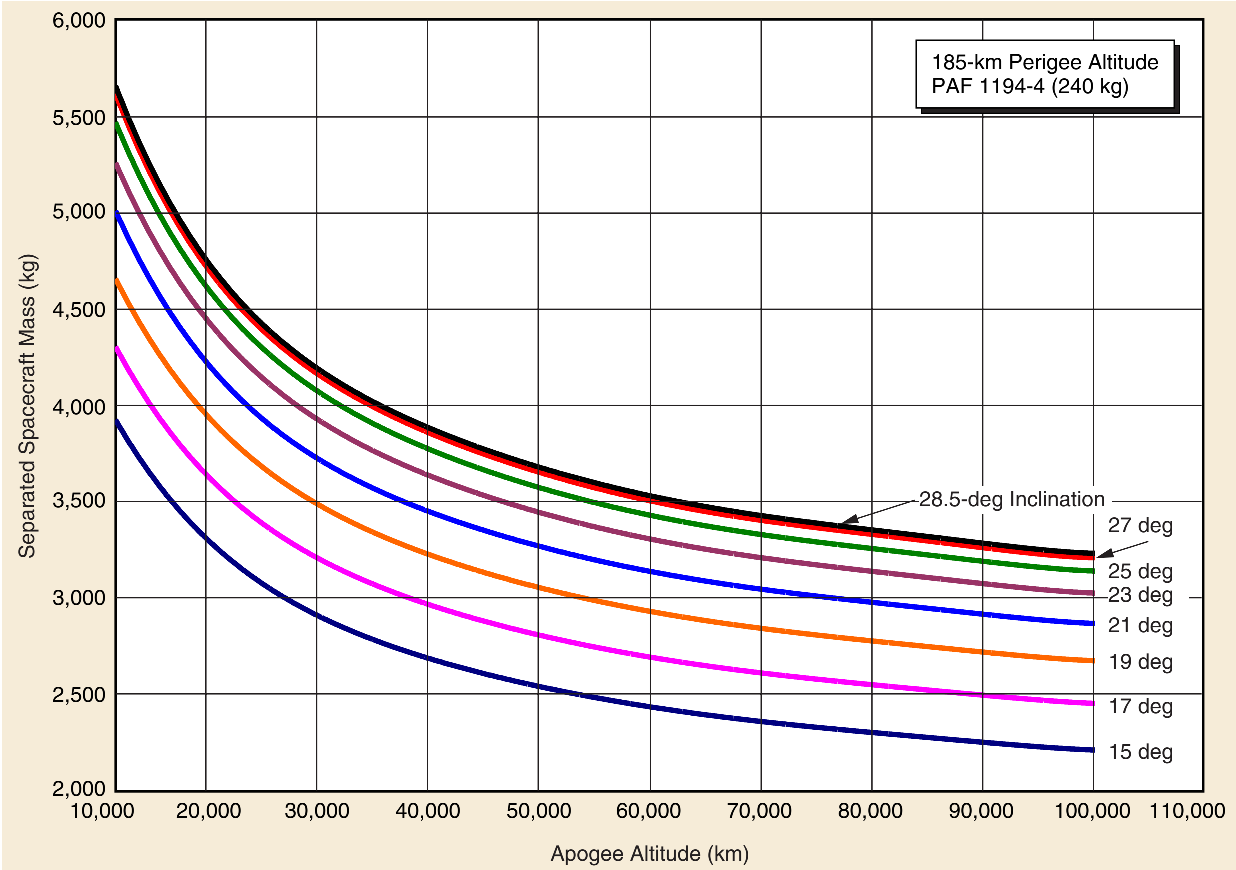
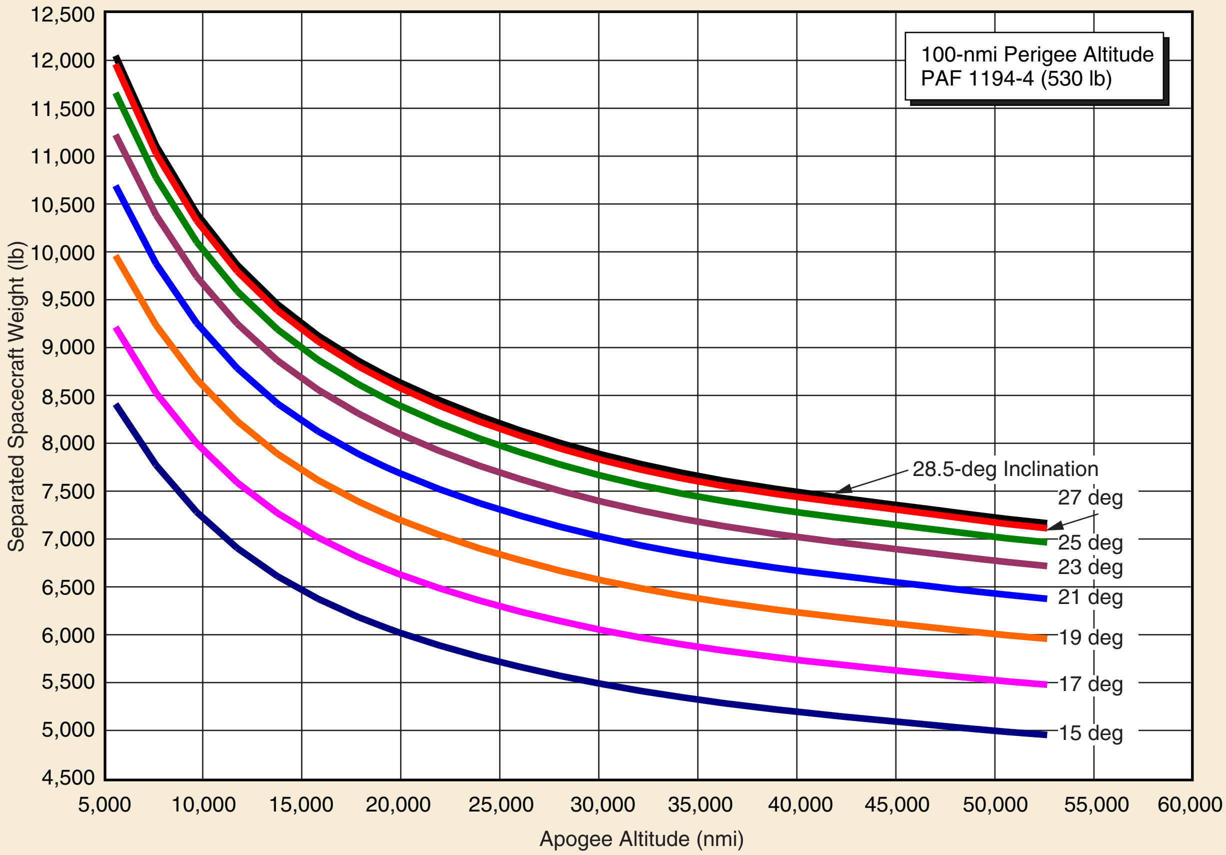



| Apogee Altitude (km)* | Separated Spacecraft Mass (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **10,000** | 5,659 | 5,618 | 5,470 | 5,260 | 5,010 | 4,658 | 4,305 | 3,926 |
| **15,000** | 5,049 | 5,012 | 4,897 | 4,716 | 4,483 | 4,186 | 3,861 | 3,514 |
| **20,000** | 4,634 | 4,601 | 4,501 | 4,338 | 4,118 | 3,854 | 3,550 | 3,225 |
| **25,000** | 4,345 | 4,316 | 4,224 | 4,072 | 3,862 | 3,617 | 3,328 | 3,021 |
| **30,000** | 4,138 | 4,111 | 4,022 | 3,877 | 3,677 | 3,443 | 3,166 | 2,871 |
| **35,786** | 3,960 | 3,934 | 3,848 | 3,709 | 3,517 | 3,291 | 3,026 | 2,742 |
| **40,000** | 3,856 | 3,830 | 3,746 | 3,610 | 3,425 | 3,203 | 2,945 | 2,667 |
| **45,000** | 3,751 | 3,725 | 3,644 | 3,512 | 3,332 | 3,115 | 2,863 | 2,592 |
| **50,000** | 3,662 | 3,635 | 3,557 | 3,428 | 3,254 | 3,040 | 2,795 | 2,529 |
| **55,000** | 3,585 | 3,559 | 3,482 | 3,357 | 3,187 | 2,977 | 2,736 | 2,475 |
| **60,000** | 3,521 | 3,495 | 3,420 | 3,297 | 3,130 | 2,923 | 2,686 | 2,429 |
| **65,000** | 3,467 | 3,442 | 3,368 | 3,247 | 3,082 | 2,877 | 2,644 | 2,389 |
| **70,000** | 3,423 | 3,398 | 3,325 | 3,205 | 3,042 | 2,839 | 2,608 | 2,356 |
| **71,572** | 3,411 | 3,386 | 3,312 | 3,193 | 3,030 | 2,828 | 2,597 | 2,346 |
| **75,000** | 3,385 | 3,362 | 3,288 | 3,169 | 3,007 | 2,805 | 2,576 | 2,327 |
| **80,000** | 3,351 | 3,328 | 3,254 | 3,136 | 2,975 | 2,775 | 2,548 | 2,301 |
| **85,000** | 3,317 | 3,294 | 3,222 | 3,105 | 2,945 | 2,747 | 2,521 | 2,275 |
| **90,000** | 3,283 | 3,260 | 3,190 | 3,074 | 2,915 | 2,719 | 2,495 | 2,251 |
| **95,000** | 3,252 | 3,228 | 3,160 | 3,045 | 2,887 | 2,693 | 2,471 | 2,228 |
| **100,000** | 3,232 | 3,210 | 3,141 | 3,026 | 2,869 | 2,675 | 2,454 | 2,212 |

*Note: Trajectories have a perigee altitude of 185 km

**Figure 2-9a. Delta IV-M Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)**

HB01987REU0.1




| Apogee Altitude (nmi)* | Separated Spacecraft Weight (lb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| 6,000 | 12,130 | 12,042 | 11,735 | 11,290 | 10,748 | 10,005 | 9,243 | 8,423 |
| 8,000 | 11,173 | 11,091 | 10,834 | 10,434 | 9,919 | 9,261 | 8,543 | 7,774 |
| 10,000 | 10,452 | 10,377 | 10,150 | 9,781 | 9,288 | 8,689 | 8,005 | 7,276 |
| 12,000 | 9,905 | 9,836 | 9,626 | 9,279 | 8,805 | 8,244 | 7,589 | 6,891 |
| 14,000 | 9,484 | 9,420 | 9,219 | 8,887 | 8,429 | 7,894 | 7,263 | 6,591 |
| 16,000 | 9,152 | 9,091 | 8,896 | 8,575 | 8,132 | 7,615 | 7,004 | 6,351 |
| 18,000 | 8,883 | 8,824 | 8,633 | 8,321 | 7,891 | 7,386 | 6,792 | 6,156 |
| 19,323 | 8,730 | 8,672 | 8,483 | 8,176 | 7,754 | 7,256 | 6,671 | 6,045 |
| 20,000 | 8,657 | 8,600 | 8,412 | 8,108 | 7,690 | 7,194 | 6,615 | 5,993 |
| 22,000 | 8,463 | 8,406 | 8,222 | 7,925 | 7,518 | 7,030 | 6,463 | 5,854 |
| 24,000 | 8,293 | 8,236 | 8,056 | 7,765 | 7,367 | 6,887 | 6,331 | 5,732 |
| 26,000 | 8,142 | 8,084 | 7,908 | 7,623 | 7,234 | 6,760 | 6,214 | 5,625 |
| 28,000 | 8,007 | 7,949 | 7,777 | 7,497 | 7,115 | 6,648 | 6,111 | 5,529 |
| 30,000 | 7,887 | 7,829 | 7,661 | 7,385 | 7,010 | 6,548 | 6,018 | 5,444 |
| 32,000 | 7,781 | 7,724 | 7,558 | 7,287 | 6,917 | 6,459 | 5,936 | 5,368 |
| 34,000 | 7,689 | 7,633 | 7,469 | 7,201 | 6,835 | 6,382 | 5,864 | 5,301 |
| 36,000 | 7,609 | 7,554 | 7,391 | 7,125 | 6,763 | 6,313 | 5,800 | 5,241 |
| 38,646 | 7,519 | 7,466 | 7,303 | 7,039 | 6,680 | 6,234 | 5,726 | 5,173 |
| 40,000 | 7,478 | 7,425 | 7,262 | 7,000 | 6,642 | 6,197 | 5,692 | 5,141 |
| 42,000 | 7,421 | 7,369 | 7,207 | 6,945 | 6,590 | 6,147 | 5,645 | 5,097 |
| 44,000 | 7,366 | 7,315 | 7,153 | 6,893 | 6,540 | 6,099 | 5,600 | 5,055 |
| 46,000 | 7,310 | 7,260 | 7,100 | 6,842 | 6,490 | 6,053 | 5,557 | 5,014 |
| 48,000 | 7,255 | 7,204 | 7,047 | 6,791 | 6,441 | 6,007 | 5,514 | 4,974 |
| 50,000 | 7,201 | 7,149 | 6,996 | 6,742 | 6,394 | 5,964 | 5,472 | 4,935 |
| 52,000 | 7,154 | 7,102 | 6,952 | 6,700 | 6,352 | 5,925 | 5,436 | 4,901 |

*Note: Trajectories have a perigee altitude of 100 nmi

**Figure 2-9b. Delta IV-M Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)**

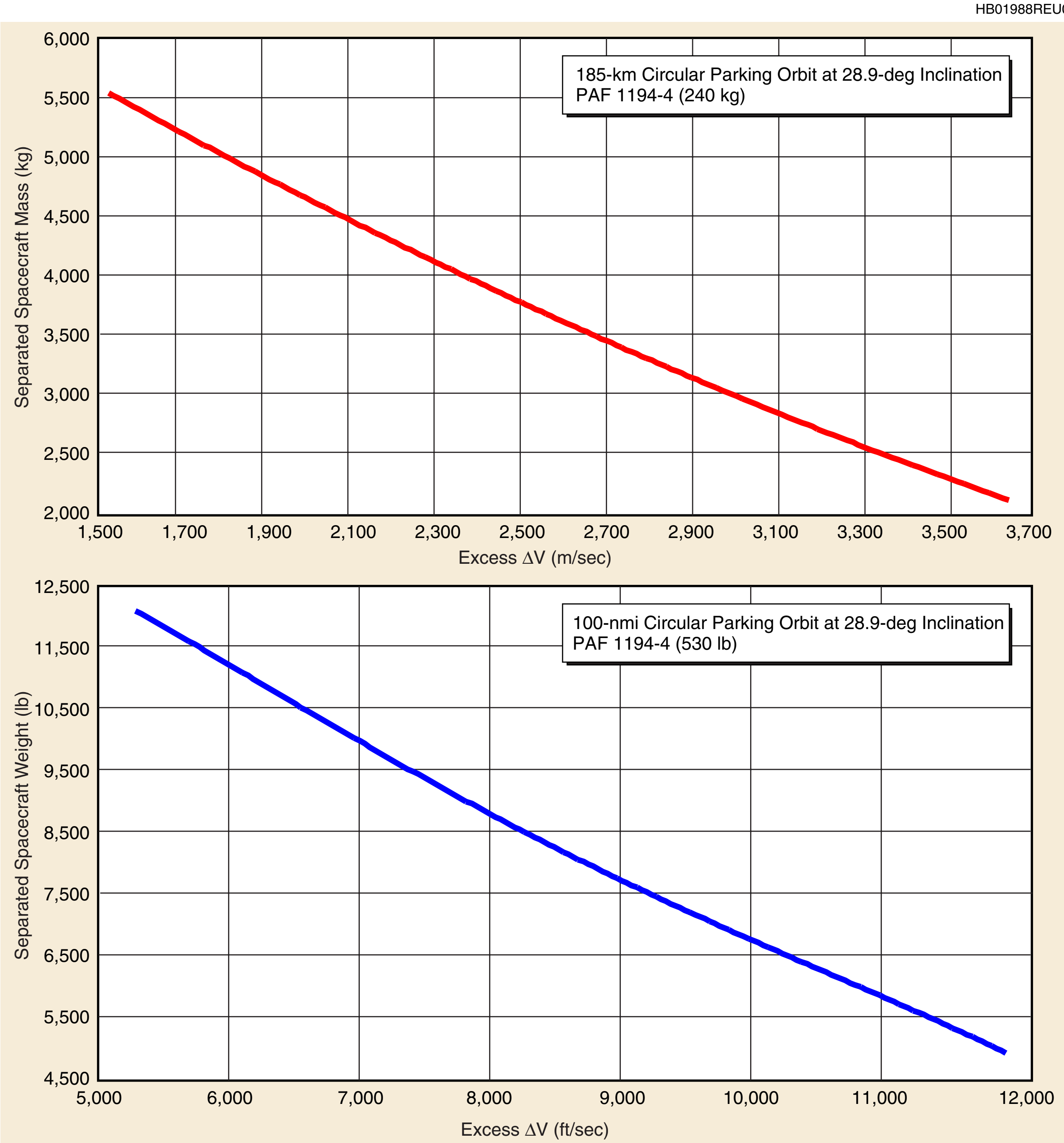



**Figure 2-10. Delta IV-M GTO Excess ∆V Capability (Eastern Range)**

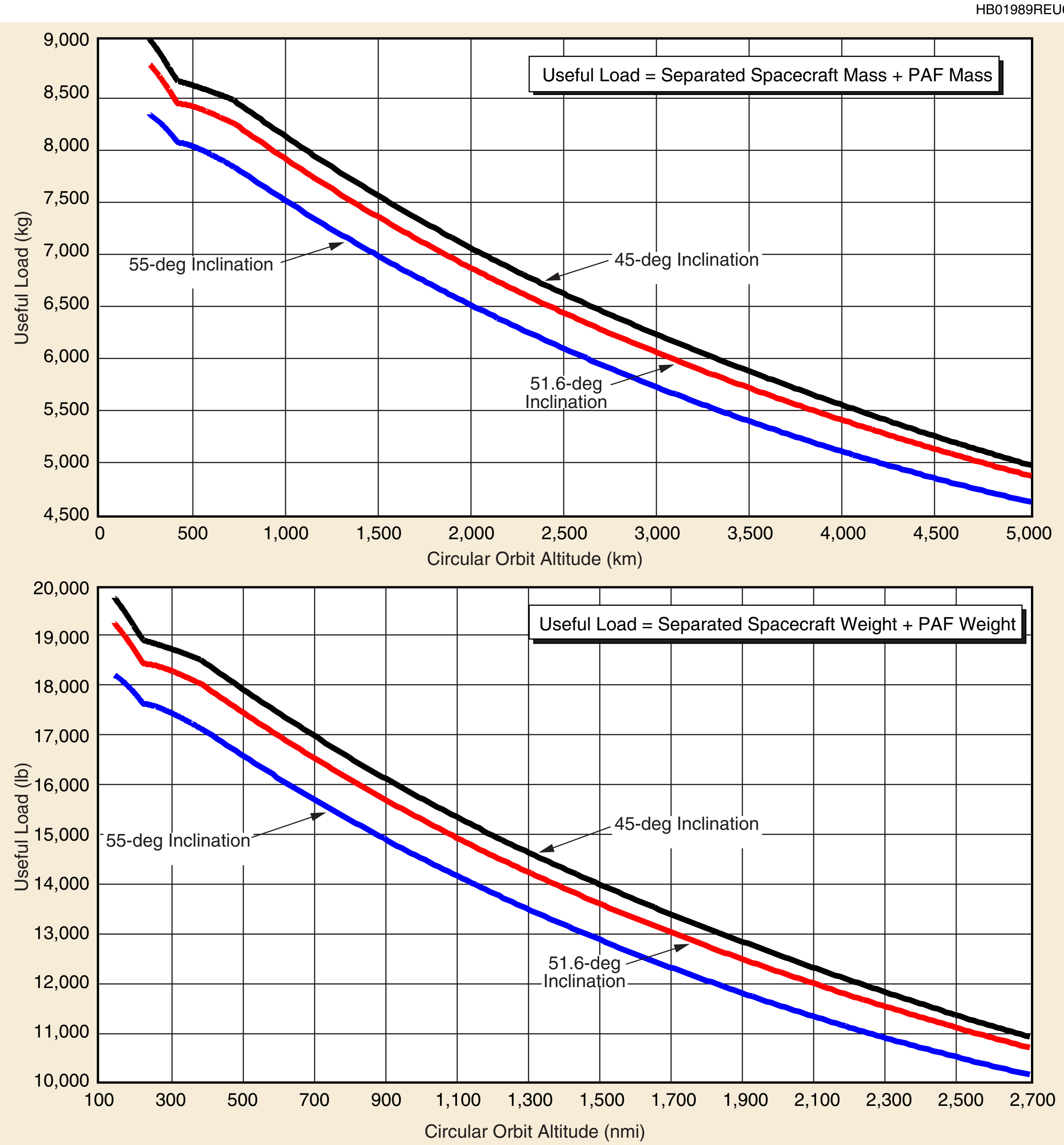



**Figure 2-11. Delta IV-M LEO Circular Orbit Capability (Eastern Range)**

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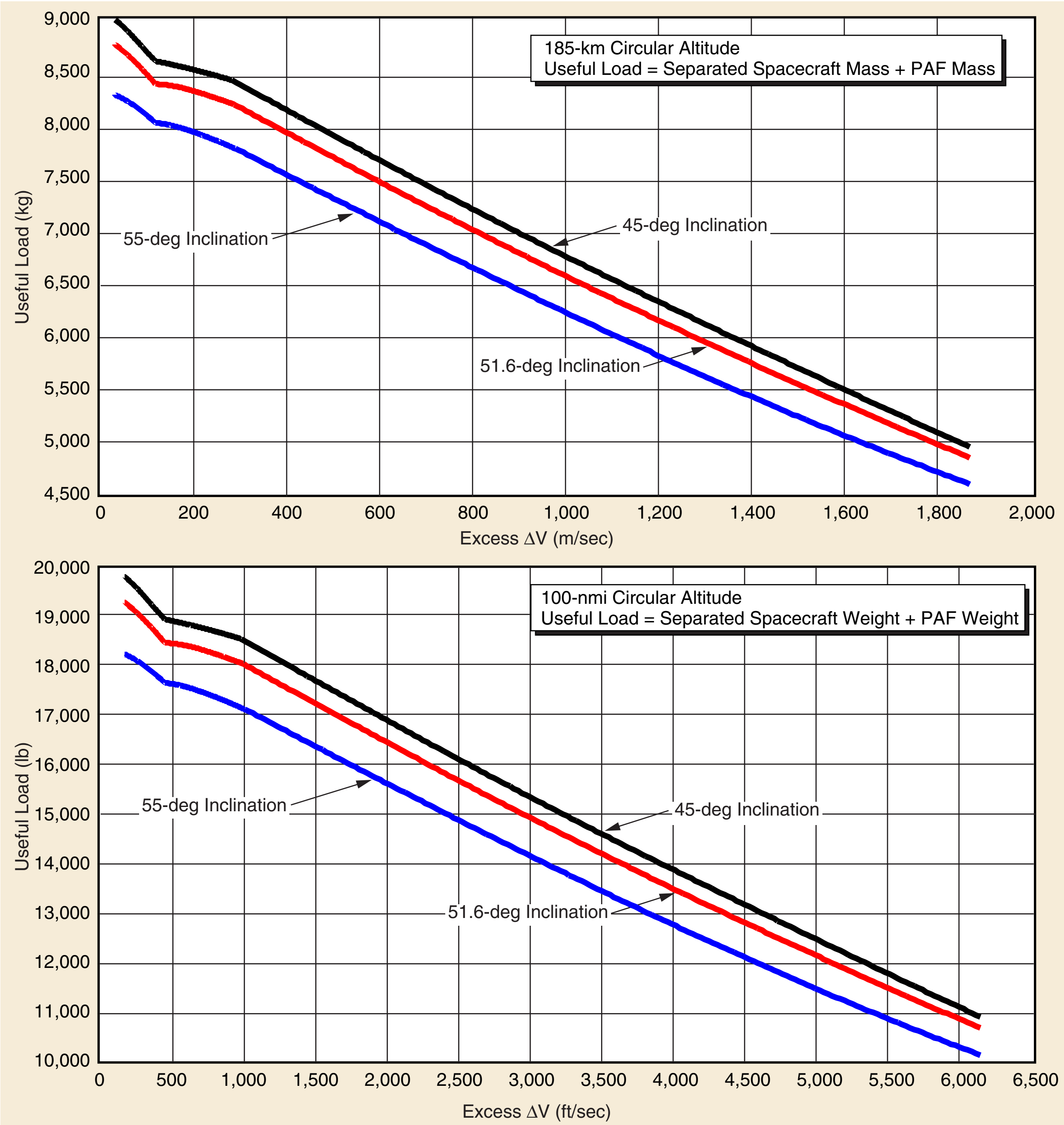



**Figure 2-12. Delta IV-M LEO Excess ΔV Capability (Eastern Range)**

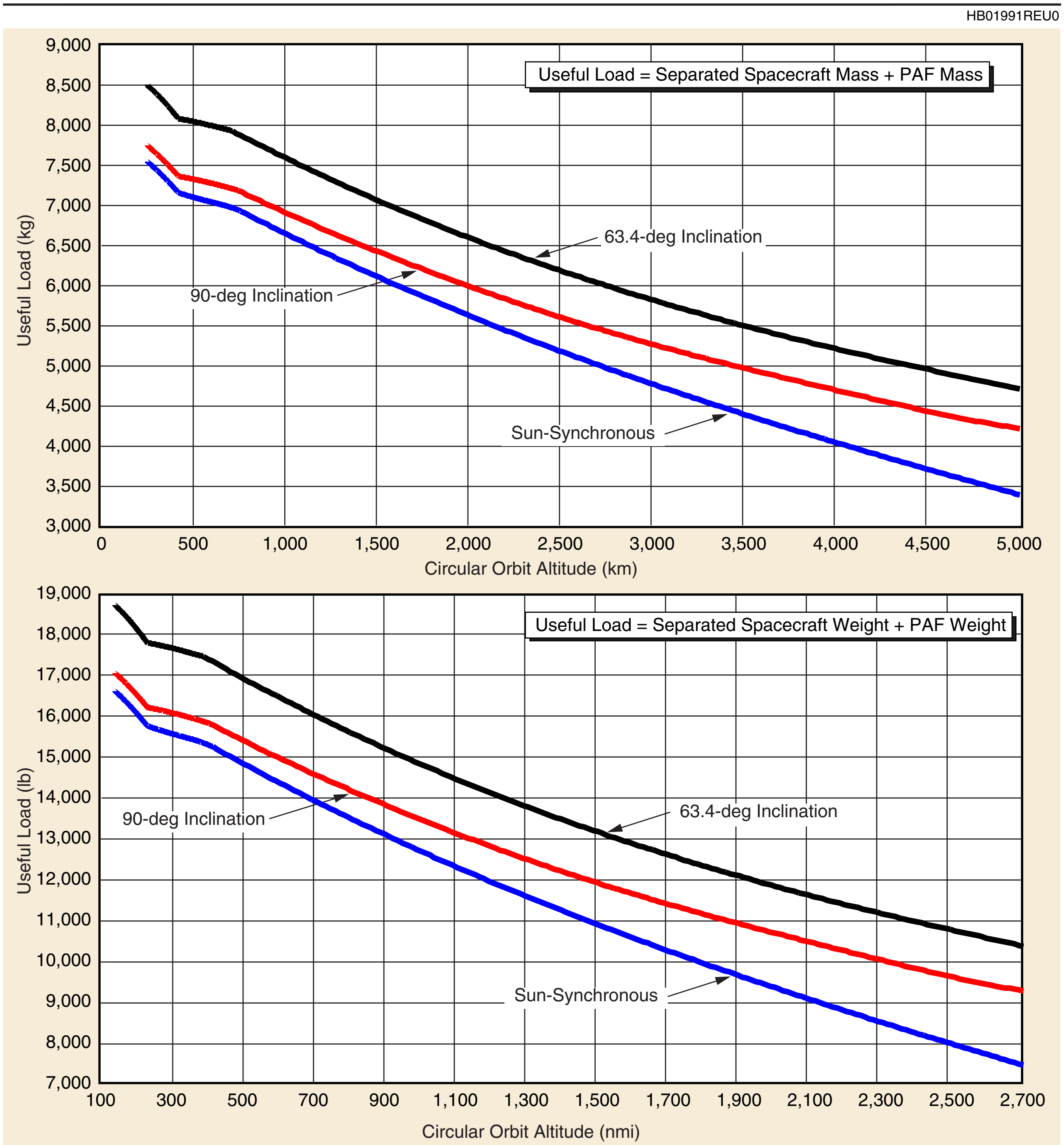



**Figure 2-13. Delta IV-M LEO Circular Orbit Capability (Western Range)**

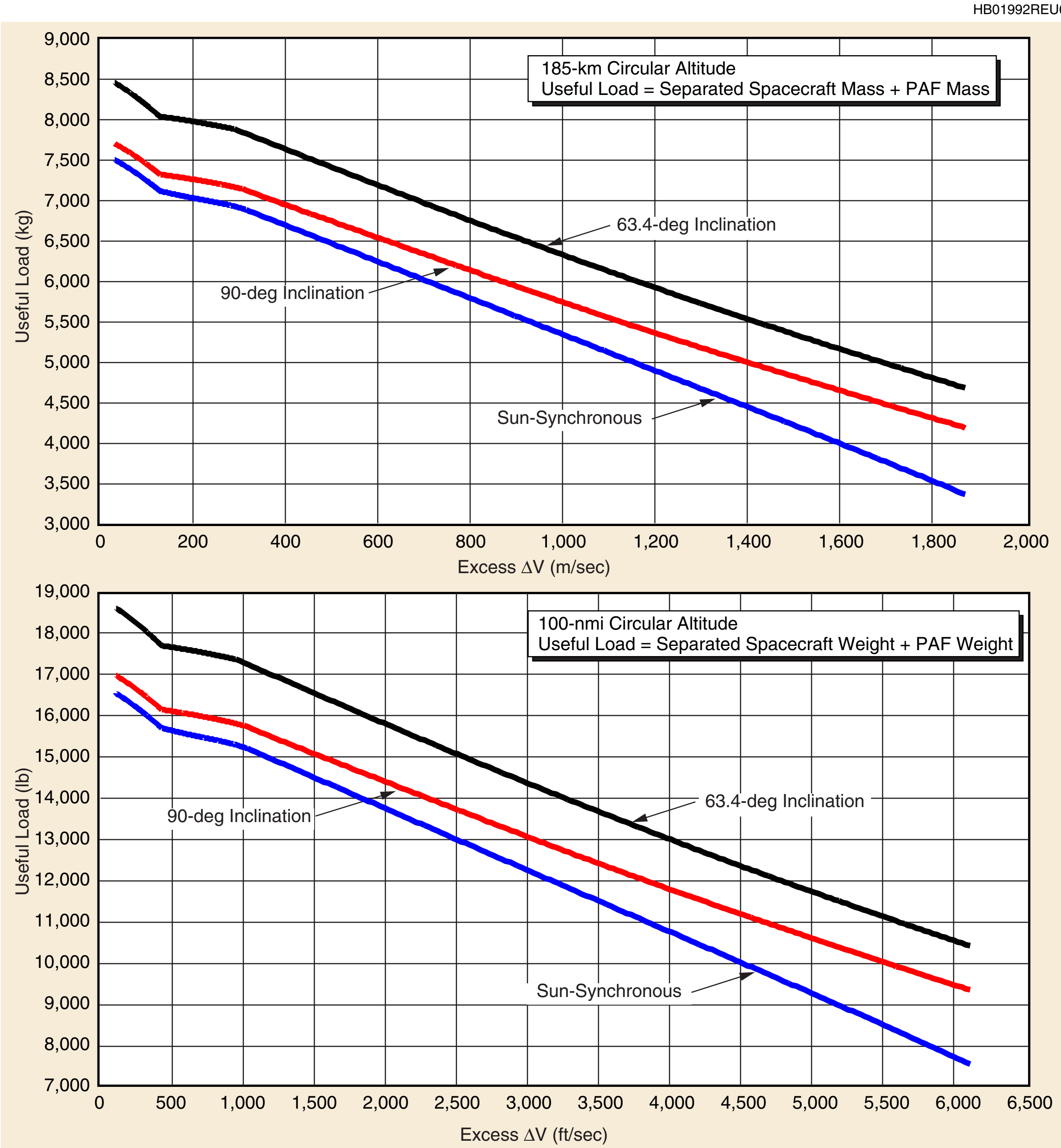
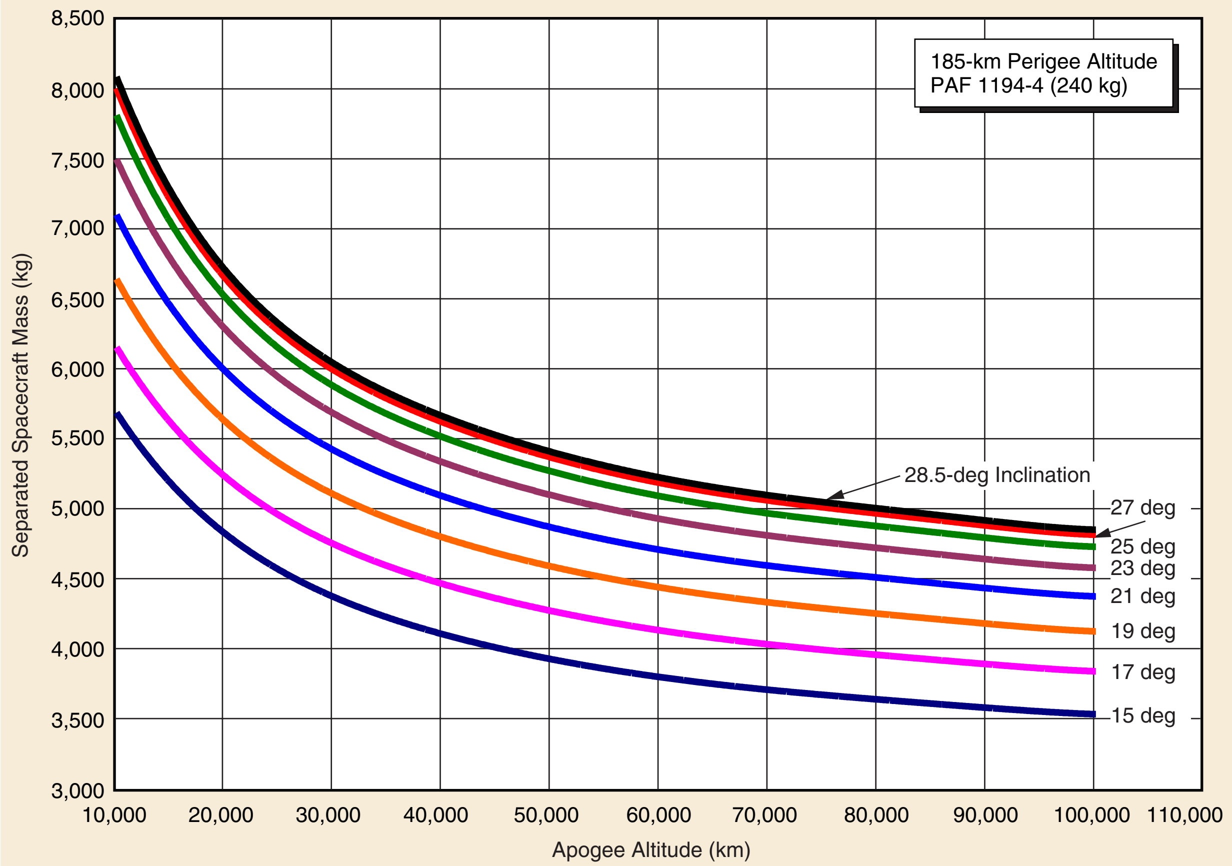



**Figure 2-14. Delta IV-M LEO Excess ΔV Capability (Western Range)**

HB01993REU0.3

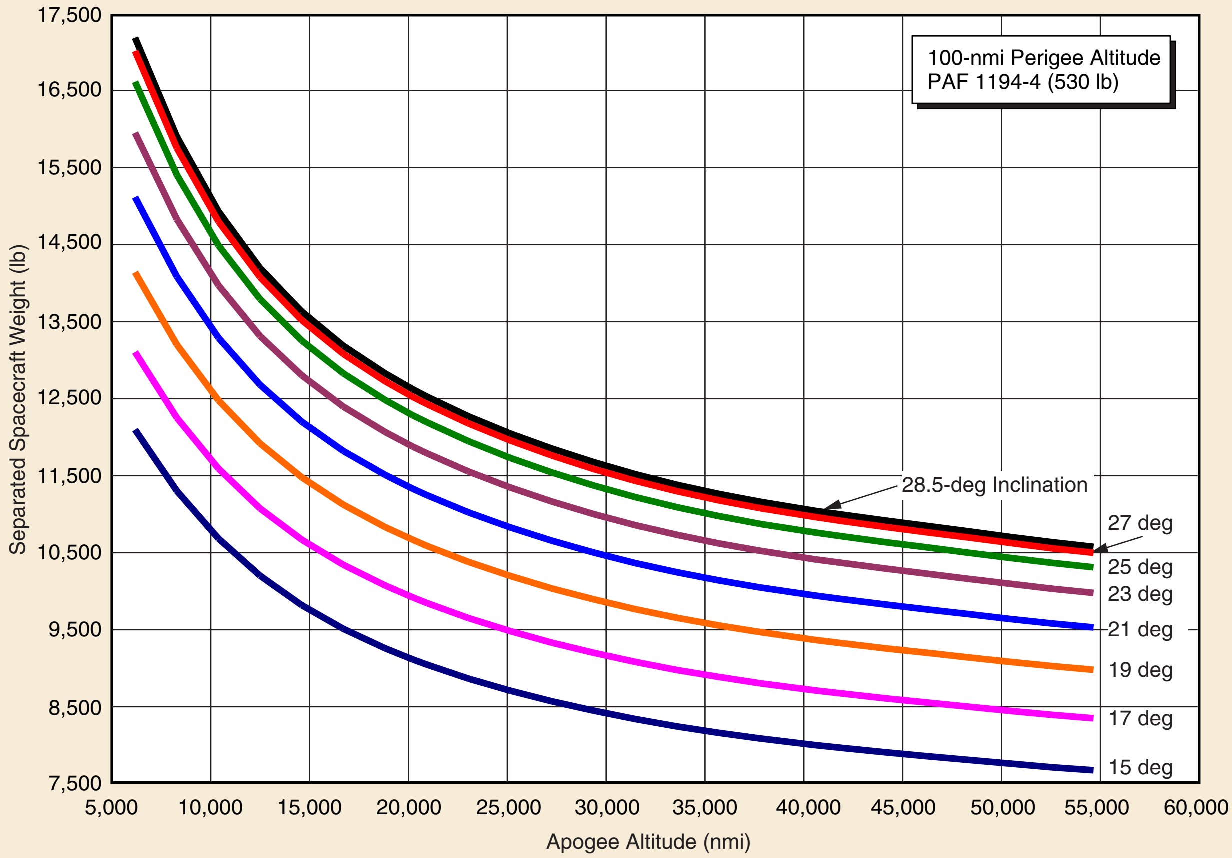



| Apogee Altitude (km)* | Separated Spacecraft Mass (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | **28.5** | **27** | **25** | **23** | **21** | **19** | **17** | **15** |
| **10,000** | 8,004 | 7,923 | 7,732 | 7,420 | 7,027 | 6,571 | 6,088 | 5,625 |
| **15,000** | 7,190 | 7,123 | 6,968 | 6,709 | 6,375 | 5,979 | 5,551 | 5,123 |
| **20,000** | 6,633 | 6,577 | 6,442 | 6,216 | 5,918 | 5,562 | 5,170 | 4,766 |
| **25,000** | 6,248 | 6,197 | 6,075 | 5,869 | 5,595 | 5,263 | 4,895 | 4,509 |
| **30,000** | 5,971 | 5,924 | 5,810 | 5,617 | 5,357 | 5,044 | 4,692 | 4,318 |
| **35,786** | 5,735 | 5,691 | 5,583 | 5,399 | 5,152 | 4,852 | 4,514 | 4,151 |
| **40,000** | 5,598 | 5,556 | 5,451 | 5,272 | 5,032 | 4,740 | 4,411 | 4,054 |
| **45,000** | 5,462 | 5,420 | 5,319 | 5,146 | 4,912 | 4,629 | 4,307 | 3,958 |
| **50,000** | 5,346 | 5,306 | 5,207 | 5,039 | 4,811 | 4,534 | 4,219 | 3,877 |
| **55,000** | 5,247 | 5,208 | 5,112 | 4,948 | 4,725 | 4,454 | 4,144 | 3,809 |
| **60,000** | 5,164 | 5,126 | 5,032 | 4,871 | 4,652 | 4,385 | 4,081 | 3,751 |
| **65,000** | 5,095 | 5,058 | 4,965 | 4,807 | 4,591 | 4,328 | 4,028 | 3,702 |
| **70,000** | 5,038 | 5,001 | 4,910 | 4,753 | 4,540 | 4,280 | 3,982 | 3,660 |
| **71,572** | 5,022 | 4,985 | 4,895 | 4,738 | 4,525 | 4,266 | 3,970 | 3,649 |
| **75,000** | 4,990 | 4,953 | 4,863 | 4,707 | 4,496 | 4,238 | 3,943 | 3,625 |
| **80,000** | 4,946 | 4,909 | 4,820 | 4,665 | 4,456 | 4,200 | 3,908 | 3,593 |
| **85,000** | 4,903 | 4,867 | 4,779 | 4,625 | 4,418 | 4,164 | 3,875 | 3,563 |
| **90,000** | 4,860 | 4,824 | 4,737 | 4,586 | 4,381 | 4,130 | 3,843 | 3,534 |
| **95,000** | 4,820 | 4,785 | 4,699 | 4,549 | 4,346 | 4,097 | 3,813 | 3,507 |
| **100,000** | 4,795 | 4,760 | 4,674 | 4,525 | 4,323 | 4,075 | 3,792 | 3,488 |

*Note: Trajectories have a perigee altitude of 185 km

**Figure 2-15a. Delta IV-M+ (4,2) Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)**

HB01994REU0.1




| Apogee Altitude (nmi)* | Separated Spacecraft Weight (lb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **6,000** | 17,184 | 17,015 | 16,614 | 15,958 | 15,125 | 14,154 | 13,122 | 12,121 |
| **8,000** | 15,905 | 15,758 | 15,413 | 14,839 | 14,098 | 13,221 | 12,274 | 11,329 |
| **10,000** | 14,941 | 14,810 | 14,503 | 13,986 | 13,310 | 12,501 | 11,617 | 10,714 |
| **12,000** | 14,209 | 14,090 | 13,808 | 13,332 | 12,701 | 11,942 | 11,104 | 10,233 |
| **14,000** | 13,646 | 13,535 | 13,271 | 12,823 | 12,225 | 11,503 | 10,699 | 9,852 |
| **16,000** | 13,203 | 13,099 | 12,846 | 12,418 | 11,845 | 11,151 | 10,373 | 9,546 |
| **18,000** | 12,846 | 12,746 | 12,502 | 12,089 | 11,534 | 10,862 | 10,105 | 9,295 |
| **19,323** | 12,643 | 12,546 | 12,307 | 11,903 | 11,357 | 10,697 | 9,952 | 9,152 |
| **20,000** | 12,548 | 12,452 | 12,216 | 11,815 | 11,274 | 10,619 | 9,880 | 9,084 |
| **22,000** | 12,294 | 12,200 | 11,970 | 11,579 | 11,051 | 10,411 | 9,687 | 8,904 |
| **24,000** | 12,071 | 11,980 | 11,756 | 11,374 | 10,857 | 10,230 | 9,518 | 8,748 |
| **26,000** | 11,875 | 11,786 | 11,566 | 11,192 | 10,685 | 10,069 | 9,370 | 8,610 |
| **28,000** | 11,700 | 11,613 | 11,398 | 11,031 | 10,532 | 9,927 | 9,237 | 8,489 |
| **30,000** | 11,545 | 11,460 | 11,249 | 10,888 | 10,397 | 9,801 | 9,120 | 8,381 |
| **32,000** | 11,409 | 11,325 | 11,118 | 10,762 | 10,278 | 9,689 | 9,016 | 8,286 |
| **34,000** | 11,291 | 11,208 | 11,003 | 10,651 | 10,173 | 9,590 | 8,925 | 8,202 |
| **36,000** | 11,188 | 11,106 | 10,904 | 10,555 | 10,081 | 9,504 | 8,844 | 8,129 |
| **38,646** | 11,072 | 10,991 | 10,791 | 10,445 | 9,976 | 9,405 | 8,751 | 8,044 |
| **40,000** | 11,019 | 10,938 | 10,739 | 10,395 | 9,928 | 9,359 | 8,709 | 8,005 |
| **42,000** | 10,946 | 10,865 | 10,668 | 10,325 | 9,862 | 9,296 | 8,650 | 7,951 |
| **44,000** | 10,876 | 10,795 | 10,599 | 10,259 | 9,798 | 9,236 | 8,594 | 7,901 |
| **46,000** | 10,806 | 10,726 | 10,531 | 10,194 | 9,736 | 9,178 | 8,540 | 7,852 |
| **48,000** | 10,735 | 10,656 | 10,464 | 10,129 | 9,675 | 9,121 | 8,487 | 7,804 |
| **50,000** | 10,666 | 10,588 | 10,398 | 10,066 | 9,617 | 9,066 | 8,437 | 7,759 |
| **52,000** | 10,607 | 10,529 | 10,341 | 10,012 | 9,565 | 9,018 | 8,392 | 7,719 |

*Note: Trajectories have a perigee altitude of 100 nmi

**Figure 2-15b. Delta IV-M+ (4,2) Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)**

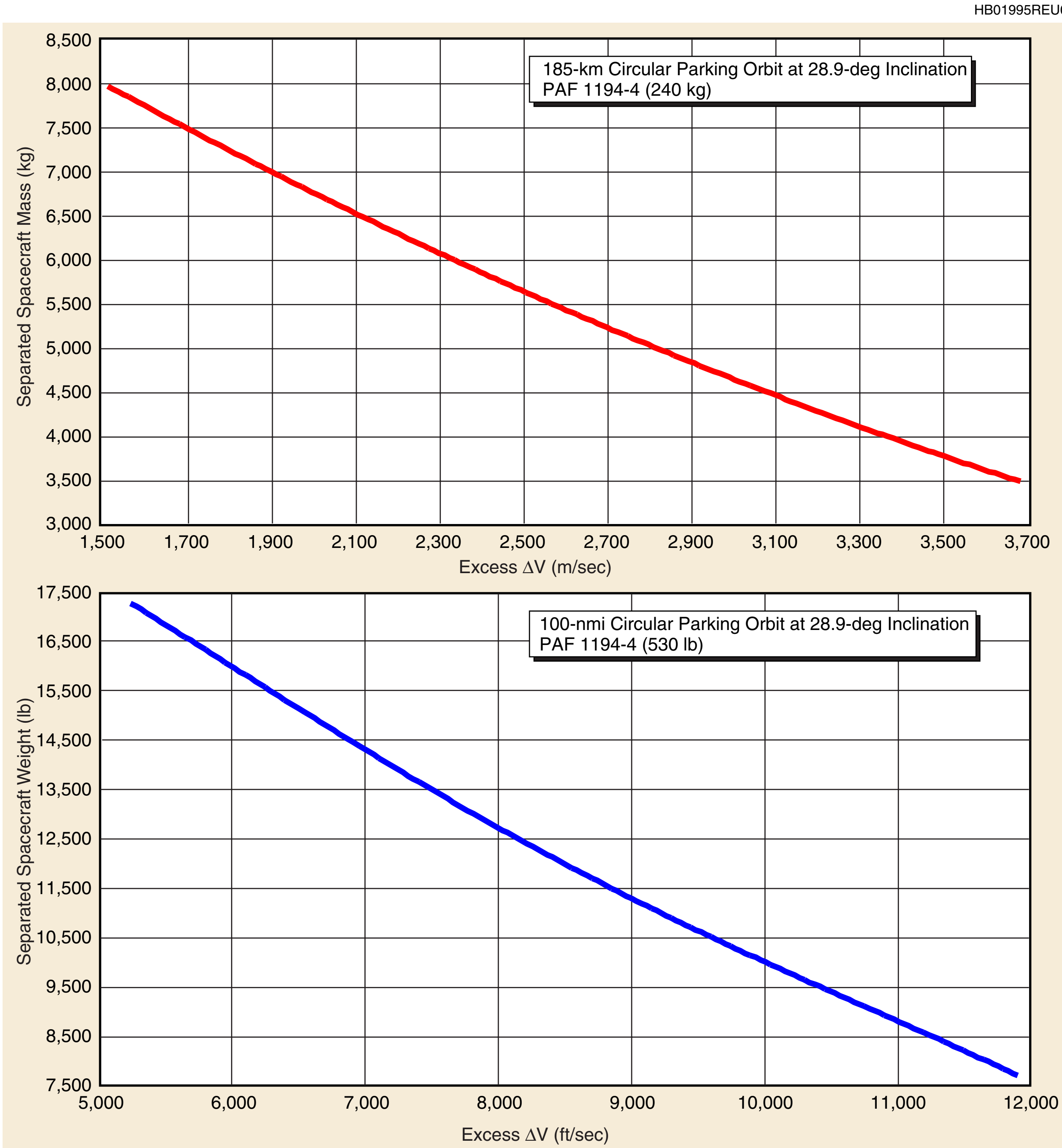



**Figure 2-16. Delta IV-M+ (4,2) GTO Excess ΔV Capability (Eastern Range)**

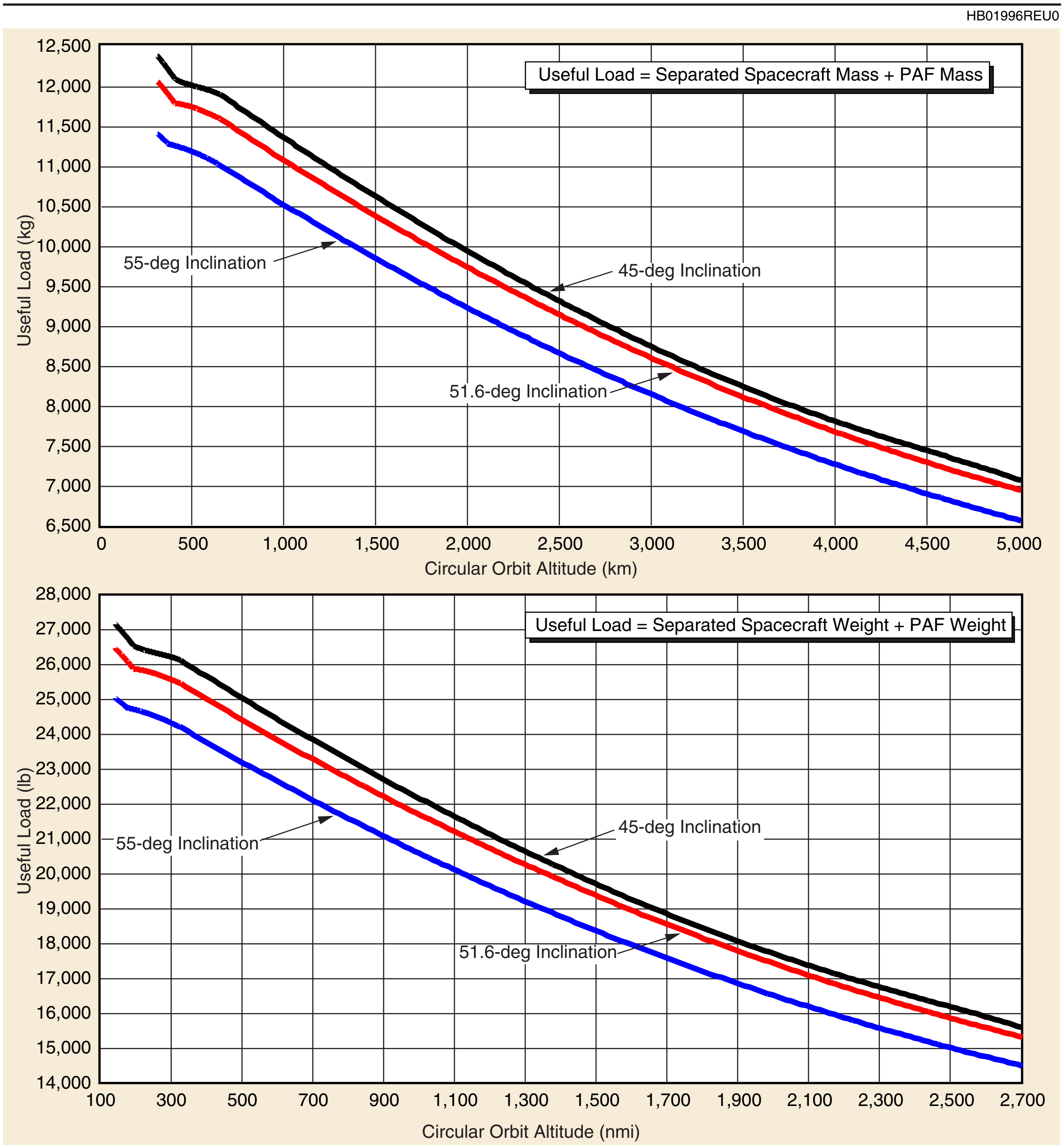



**Figure 2-17. Delta IV-M+ (4,2) LEO Circular Capability (Eastern Range)**

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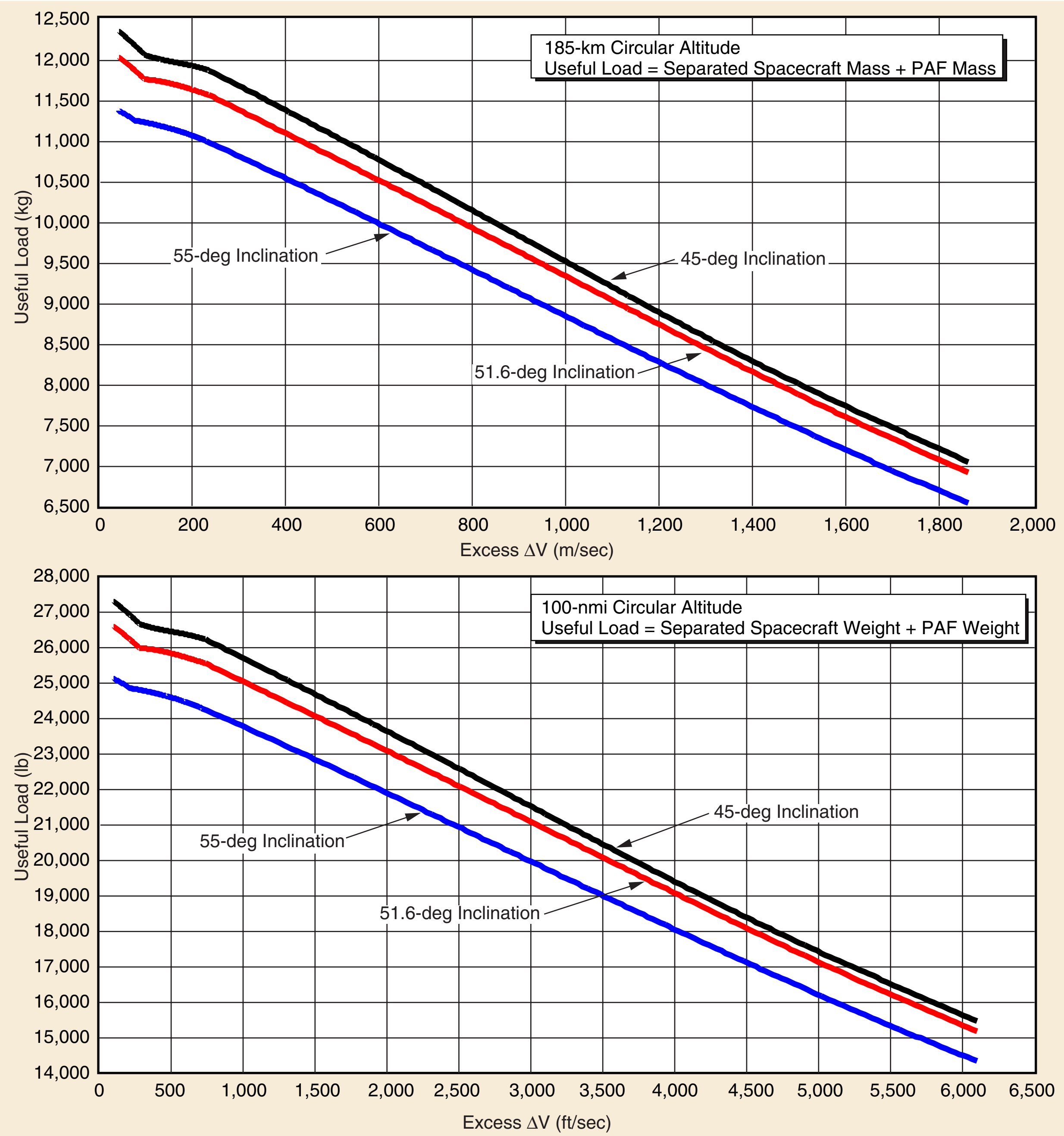



**Figure 2-18. Delta IV-M+ (4,2) LEO Excess ∆V Capability (Eastern Range)**

HB01998REU0

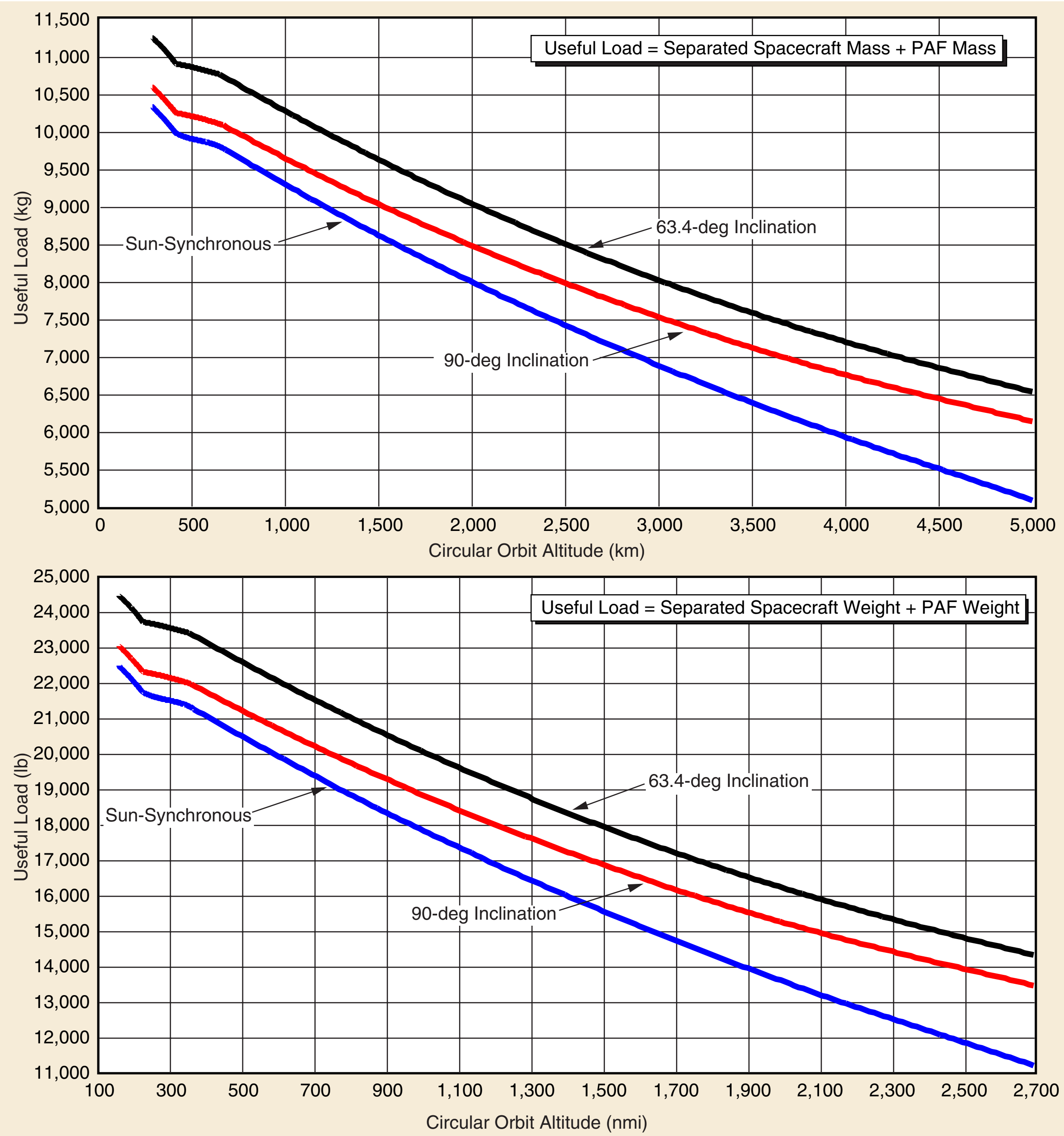



**Figure 2-19. Delta IV-M+ (4,2) LEO Circular Orbit Capability (Western Range)**

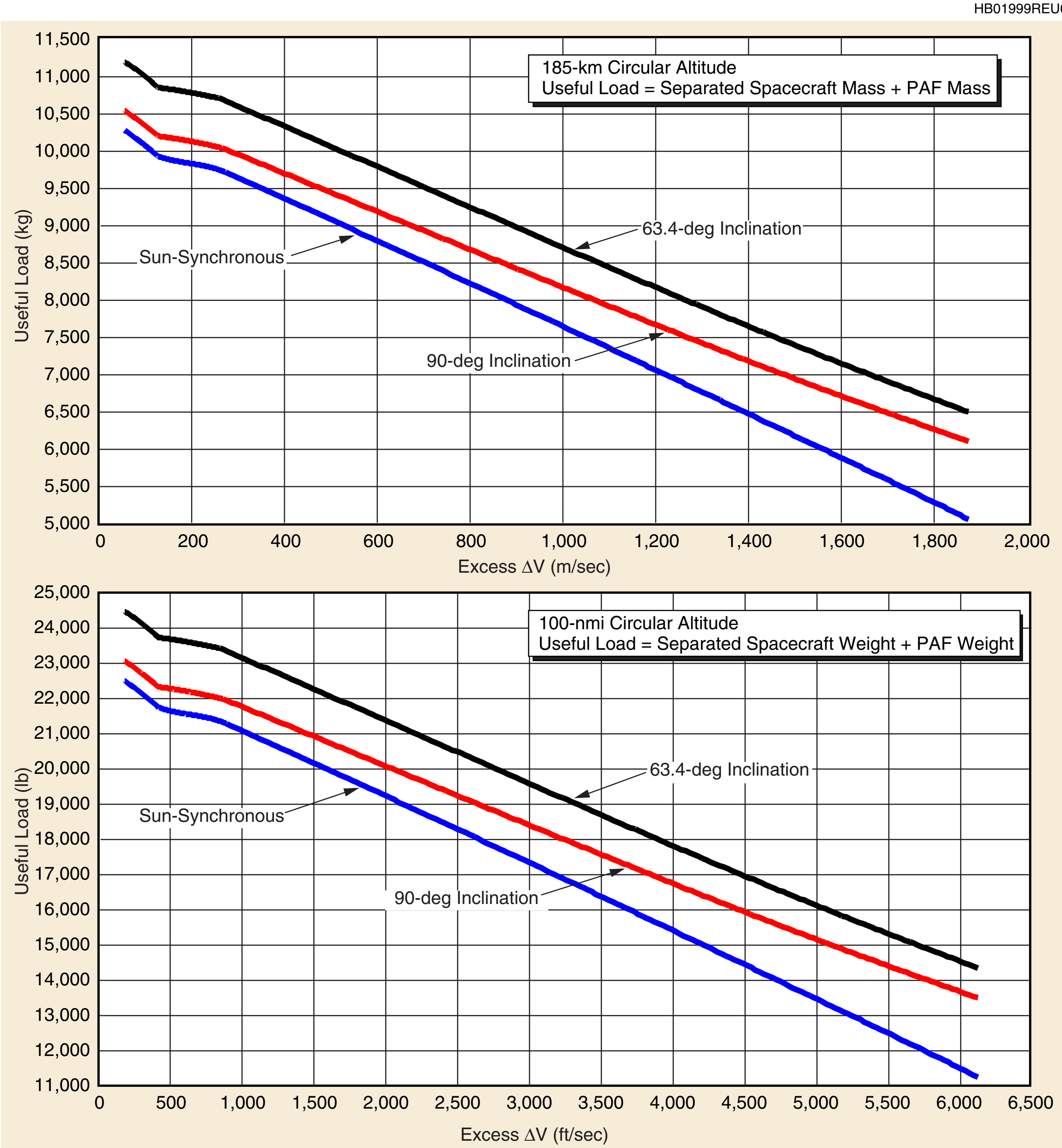
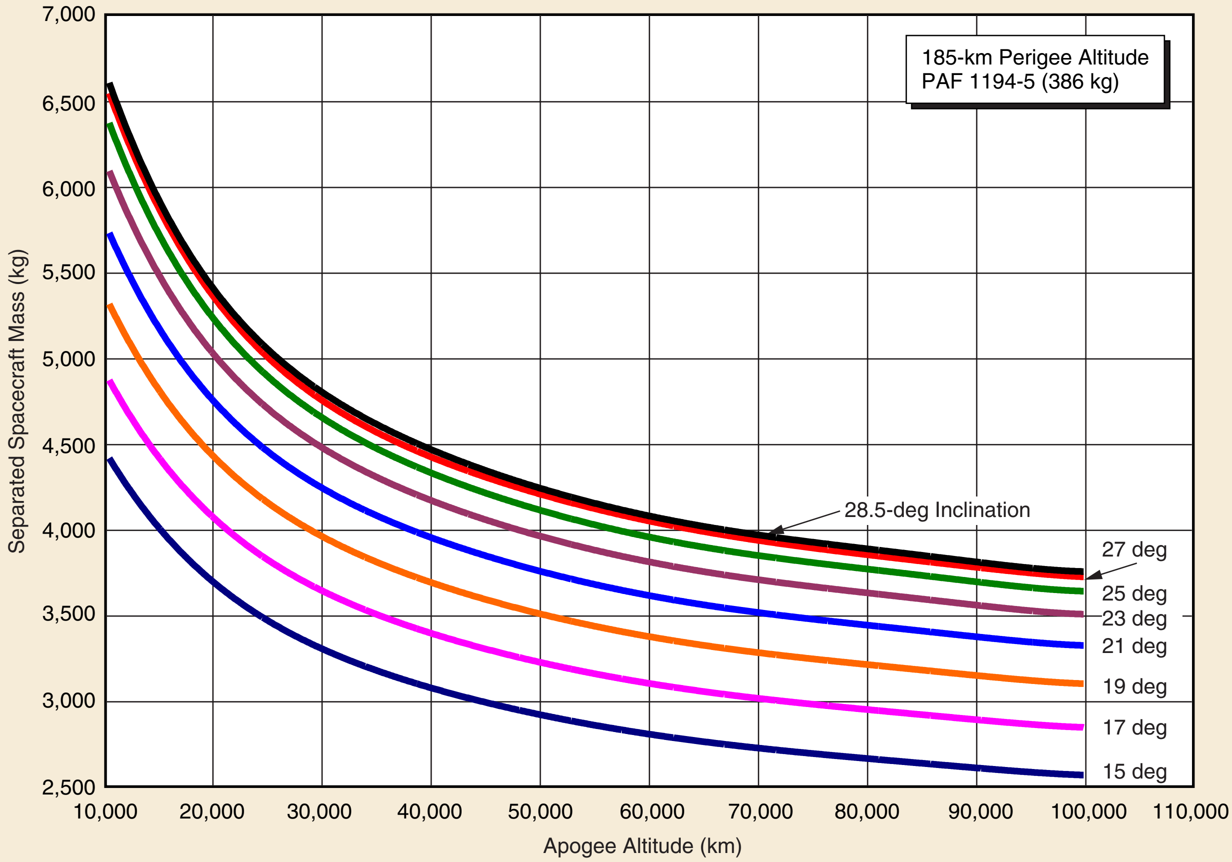



**Figure 2-20. Delta IV-M+ (4,2) LEO Excess ΔV Capability (Western Range)**

HB02000REU0.2

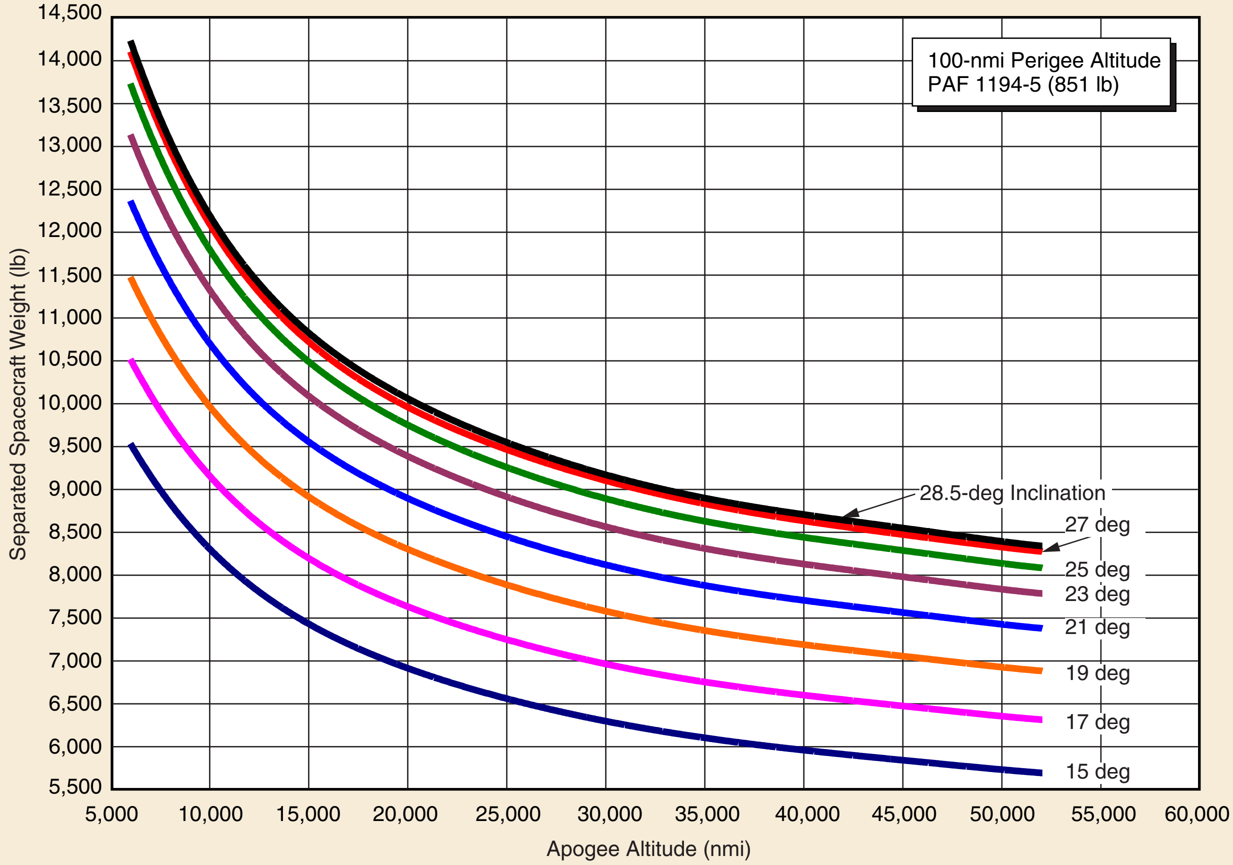



| Apogee Altitude (km)* | Separated Spacecraft Mass (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **10,000** | 6,611 | 6,551 | 6,377 | 6,097 | 5,736 | 5,321 | 4,878 | 4,423 |
| **15,000** | 5,877 | 5,829 | 5,681 | 5,447 | 5,141 | 4,783 | 4,393 | 3,986 |
| **20,000** | 5,379 | 5,334 | 5,207 | 5,002 | 4,731 | 4,410 | 4,055 | 3,681 |
| **25,000** | 5,037 | 4,990 | 4,879 | 4,693 | 4,444 | 4,147 | 3,815 | 3,462 |
| **30,000** | 4,793 | 4,745 | 4,645 | 4,471 | 4,237 | 3,955 | 3,639 | 3,302 |
| **35,786** | 4,586 | 4,540 | 4,446 | 4,280 | 4,058 | 3,789 | 3,486 | 3,161 |
| **40,000** | 4,466 | 4,423 | 4,330 | 4,170 | 3,954 | 3,692 | 3,396 | 3,078 |
| **45,000** | 4,346 | 4,307 | 4,214 | 4,059 | 3,849 | 3,595 | 3,306 | 2,995 |
| **50,000** | 4,244 | 4,209 | 4,116 | 3,965 | 3,760 | 3,512 | 3,230 | 2,924 |
| **55,000** | 4,157 | 4,126 | 4,032 | 3,884 | 3,684 | 3,441 | 3,164 | 2,864 |
| **60,000** | 4,084 | 4,054 | 3,961 | 3,816 | 3,620 | 3,381 | 3,108 | 2,812 |
| **65,000** | 4,024 | 3,994 | 3,903 | 3,760 | 3,567 | 3,331 | 3,061 | 2,769 |
| **70,000** | 3,974 | 3,943 | 3,855 | 3,713 | 3,522 | 3,288 | 3,022 | 2,732 |
| **71,572** | 3,961 | 3,928 | 3,841 | 3,700 | 3,509 | 3,276 | 3,011 | 2,722 |
| **75,000** | 3,932 | 3,899 | 3,813 | 3,674 | 3,484 | 3,252 | 2,988 | 2,700 |
| **80,000** | 3,894 | 3,860 | 3,776 | 3,637 | 3,449 | 3,219 | 2,957 | 2,672 |
| **85,000** | 3,856 | 3,823 | 3,740 | 3,602 | 3,415 | 3,188 | 2,927 | 2,644 |
| **90,000** | 3,818 | 3,787 | 3,703 | 3,566 | 3,382 | 3,156 | 2,898 | 2,617 |
| **95,000** | 3,783 | 3,754 | 3,668 | 3,534 | 3,351 | 3,127 | 2,871 | 2,592 |
| **100,000** | 3,762 | 3,731 | 3,647 | 3,513 | 3,331 | 3,108 | 2,853 | 2,575 |

*Note: Trajectories have a perigee altitude of 185 km

**Figure 2-21a. Delta IV-M+ (5,2) Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)**

HB02001REU0




| Apogee Altitude (nmi)* | Separated Spacecraft Weight (lb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **6,000** | 14,158 | 14,035 | 13,664 | 13,074 | 12,310 | 11,428 | 10,481 | 9,506 |
| **8,000** | 13,005 | 12,900 | 12,570 | 12,052 | 11,373 | 10,581 | 9,717 | 8,818 |
| **10,000** | 12,141 | 12,041 | 11,748 | 11,281 | 10,663 | 9,935 | 9,133 | 8,290 |
| **12,000** | 11,489 | 11,388 | 11,126 | 10,695 | 10,121 | 9,439 | 8,682 | 7,881 |
| **14,000** | 10,991 | 10,887 | 10,649 | 10,243 | 9,701 | 9,053 | 8,330 | 7,559 |
| **16,000** | 10,601 | 10,496 | 10,274 | 9,888 | 9,369 | 8,747 | 8,048 | 7,301 |
| **18,000** | 10,287 | 10,183 | 9,972 | 9,600 | 9,099 | 8,496 | 7,817 | 7,090 |
| **19,323** | 10,109 | 10,008 | 9,801 | 9,436 | 8,946 | 8,353 | 7,685 | 6,968 |
| **20,000** | 10,026 | 9,926 | 9,721 | 9,359 | 8,873 | 8,286 | 7,623 | 6,911 |
| **22,000** | 9,803 | 9,709 | 9,505 | 9,154 | 8,679 | 8,105 | 7,456 | 6,757 |
| **24,000** | 9,608 | 9,521 | 9,317 | 8,973 | 8,509 | 7,947 | 7,310 | 6,622 |
| **26,000** | 9,435 | 9,356 | 9,150 | 8,813 | 8,359 | 7,806 | 7,179 | 6,502 |
| **28,000** | 9,281 | 9,208 | 9,001 | 8,671 | 8,225 | 7,681 | 7,063 | 6,395 |
| **30,000** | 9,145 | 9,077 | 8,870 | 8,545 | 8,105 | 7,570 | 6,960 | 6,300 |
| **32,000** | 9,026 | 8,960 | 8,754 | 8,434 | 8,000 | 7,472 | 6,869 | 6,215 |
| **34,000** | 8,922 | 8,856 | 8,654 | 8,337 | 7,908 | 7,385 | 6,789 | 6,141 |
| **36,000** | 8,832 | 8,765 | 8,566 | 8,253 | 7,828 | 7,310 | 6,718 | 6,076 |
| **38,646** | 8,732 | 8,660 | 8,468 | 8,158 | 7,737 | 7,223 | 6,637 | 6,000 |
| **40,000** | 8,686 | 8,612 | 8,423 | 8,114 | 7,695 | 7,184 | 6,600 | 5,965 |
| **42,000** | 8,622 | 8,547 | 8,361 | 8,054 | 7,637 | 7,129 | 6,549 | 5,917 |
| **44,000** | 8,561 | 8,485 | 8,301 | 7,996 | 7,582 | 7,077 | 6,500 | 5,872 |
| **46,000** | 8,499 | 8,425 | 8,241 | 7,938 | 7,527 | 7,025 | 6,451 | 5,827 |
| **48,000** | 8,436 | 8,366 | 8,181 | 7,880 | 7,472 | 6,973 | 6,404 | 5,783 |
| **50,000** | 8,375 | 8,310 | 8,122 | 7,823 | 7,419 | 6,924 | 6,358 | 5,740 |
| **52,000** | 8,323 | 8,260 | 8,071 | 7,775 | 7,373 | 6,880 | 6,317 | 5,703 |

*Note: Trajectories have a perigee altitude of 100 nmi

**Figure 2-21b. Delta IV-M+ (5,2) Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)**

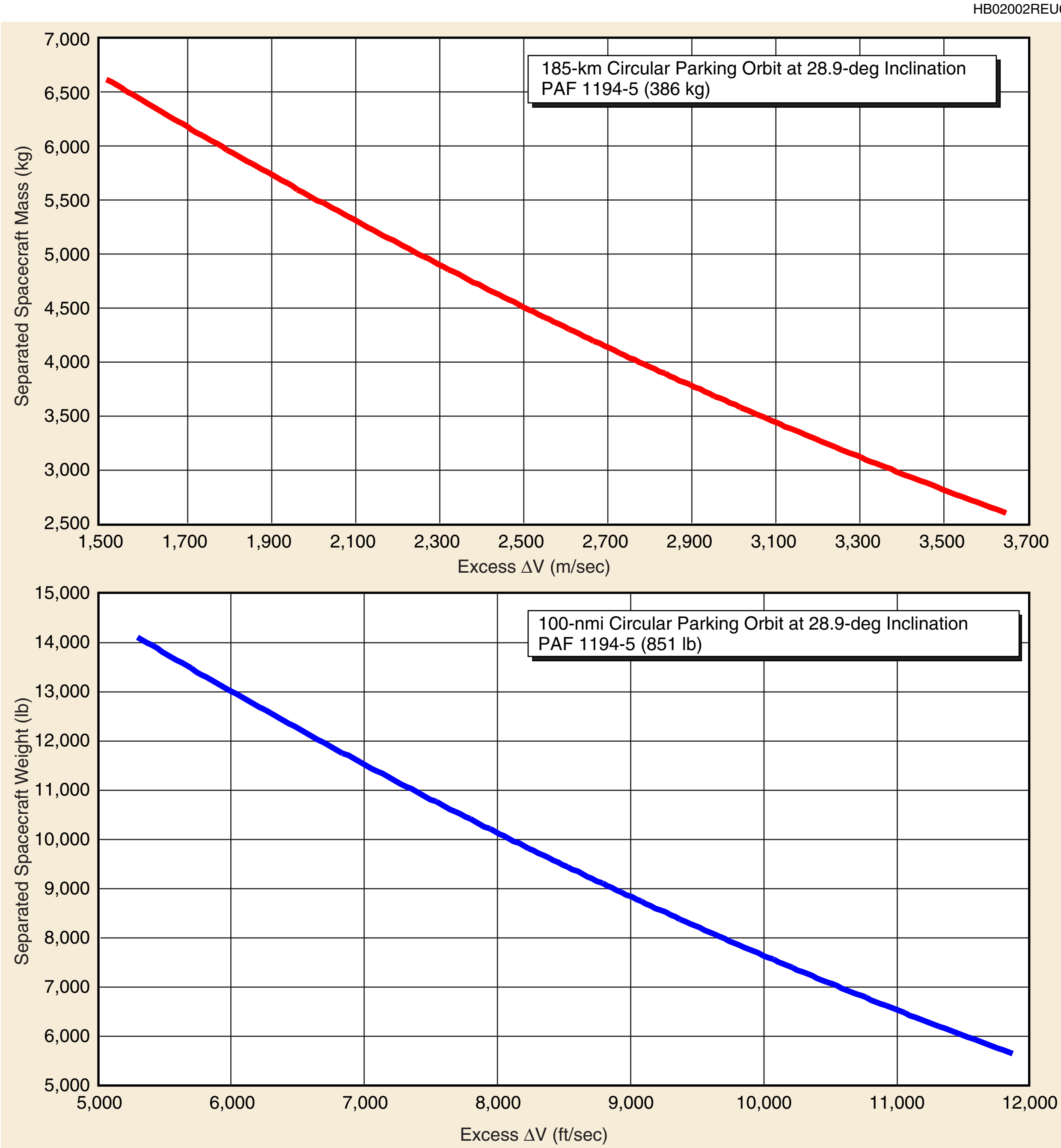



**Figure 2-22. Delta IV-M+ (5,2) GTO Excess ΔV Capability (Eastern Range)**

HB02003REU0

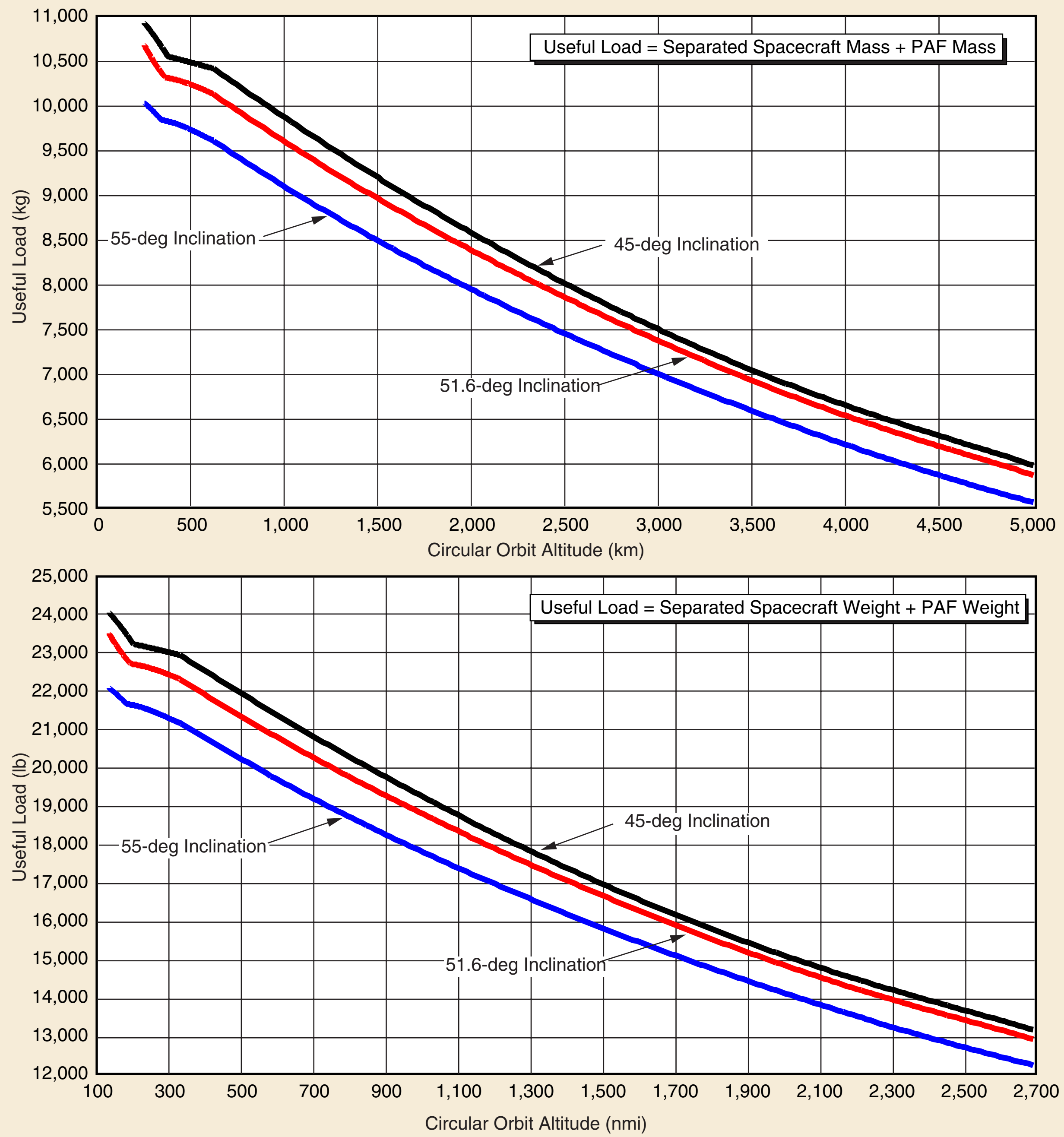



**Figure 2-23. Delta IV-M+ (5,2) LEO Circular Orbit Capability (Eastern Range)**

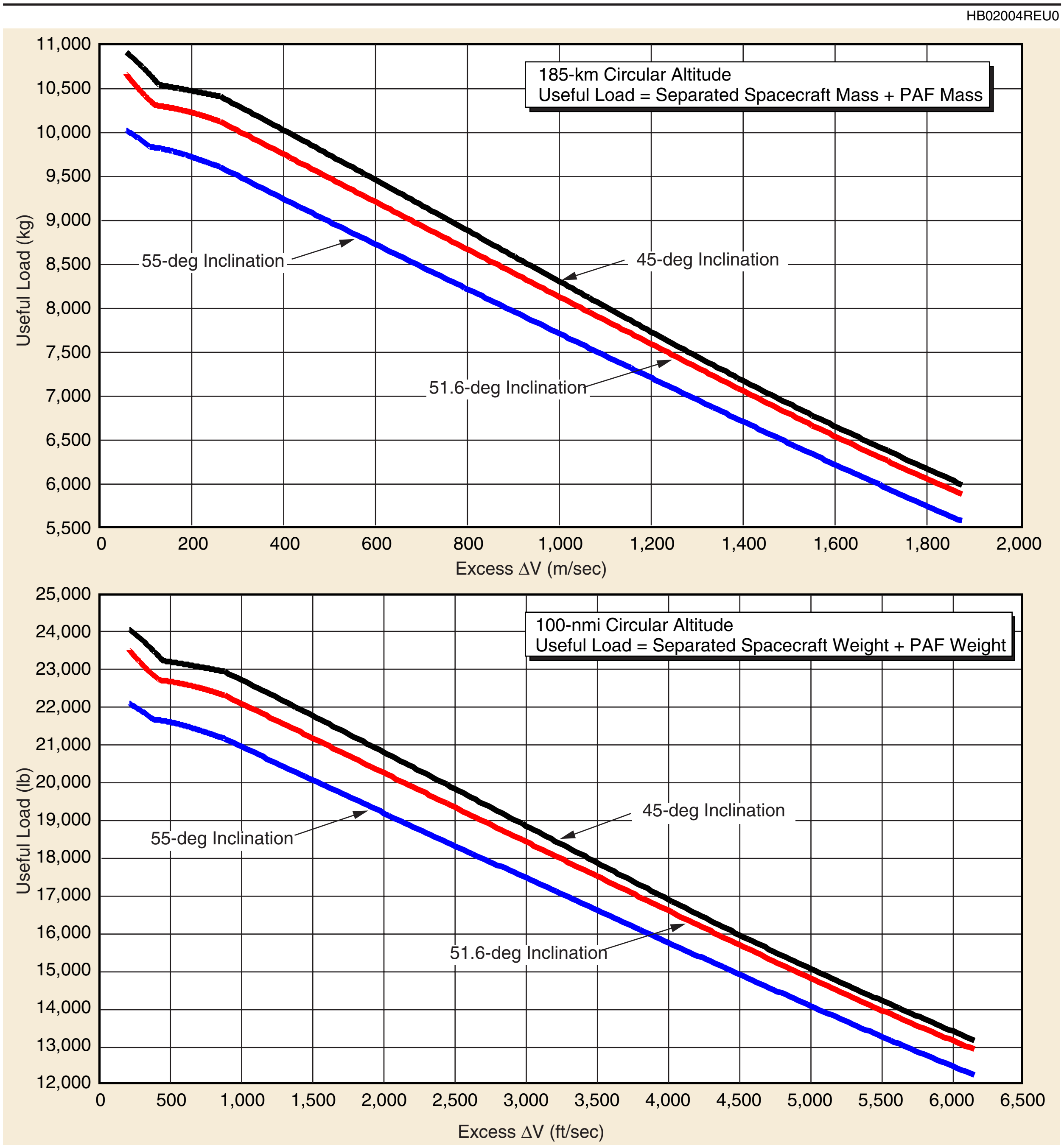



**Figure 2-24. Delta IV-M+ (5,2) LEO Excess ΔV Capability (Eastern Range)**

HB02005REU0

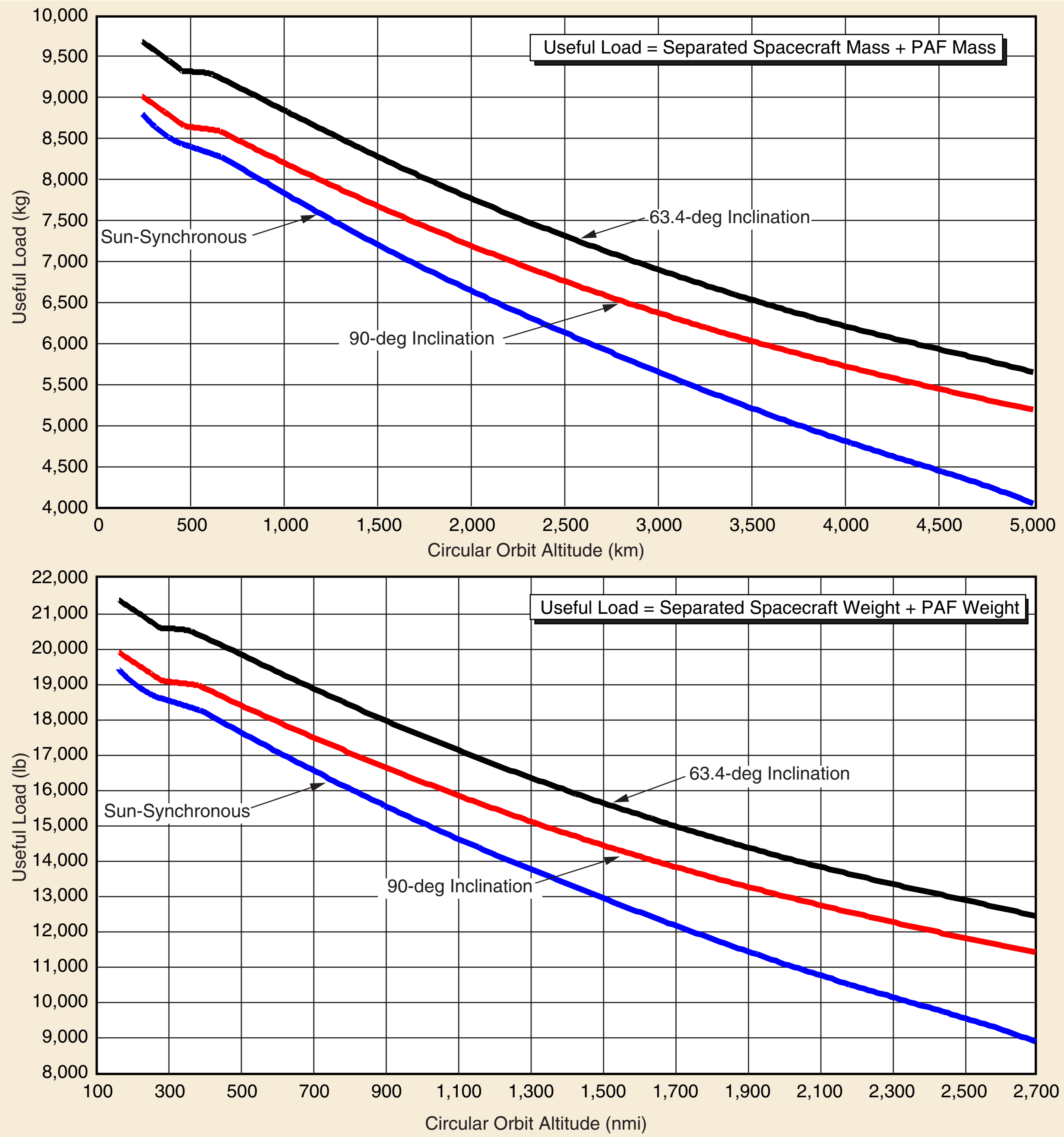



**Figure 2-25. Delta IV-M+ (5,2) LEO Circular Orbit Capability (Western Range)**

HB02115REU0

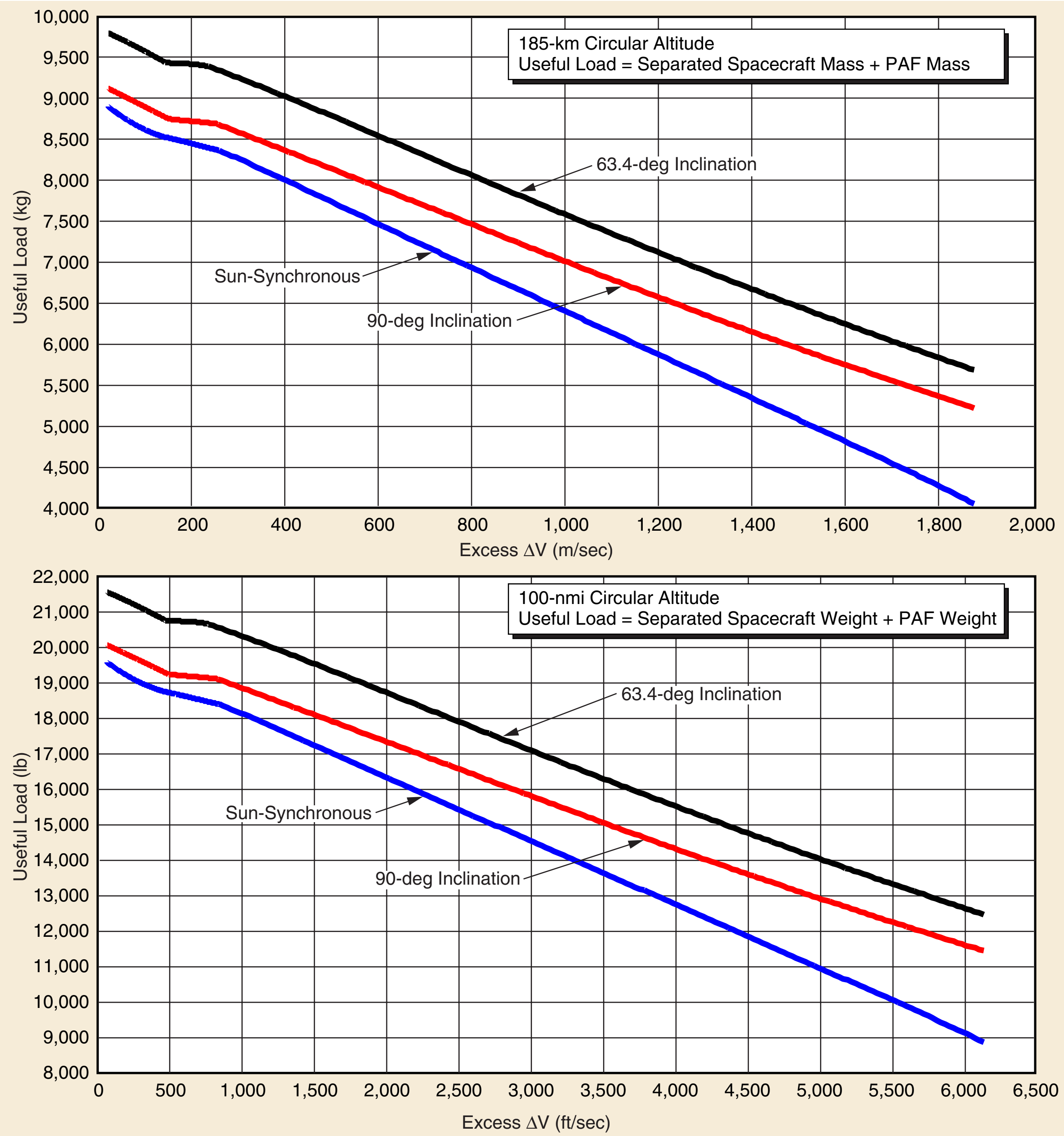
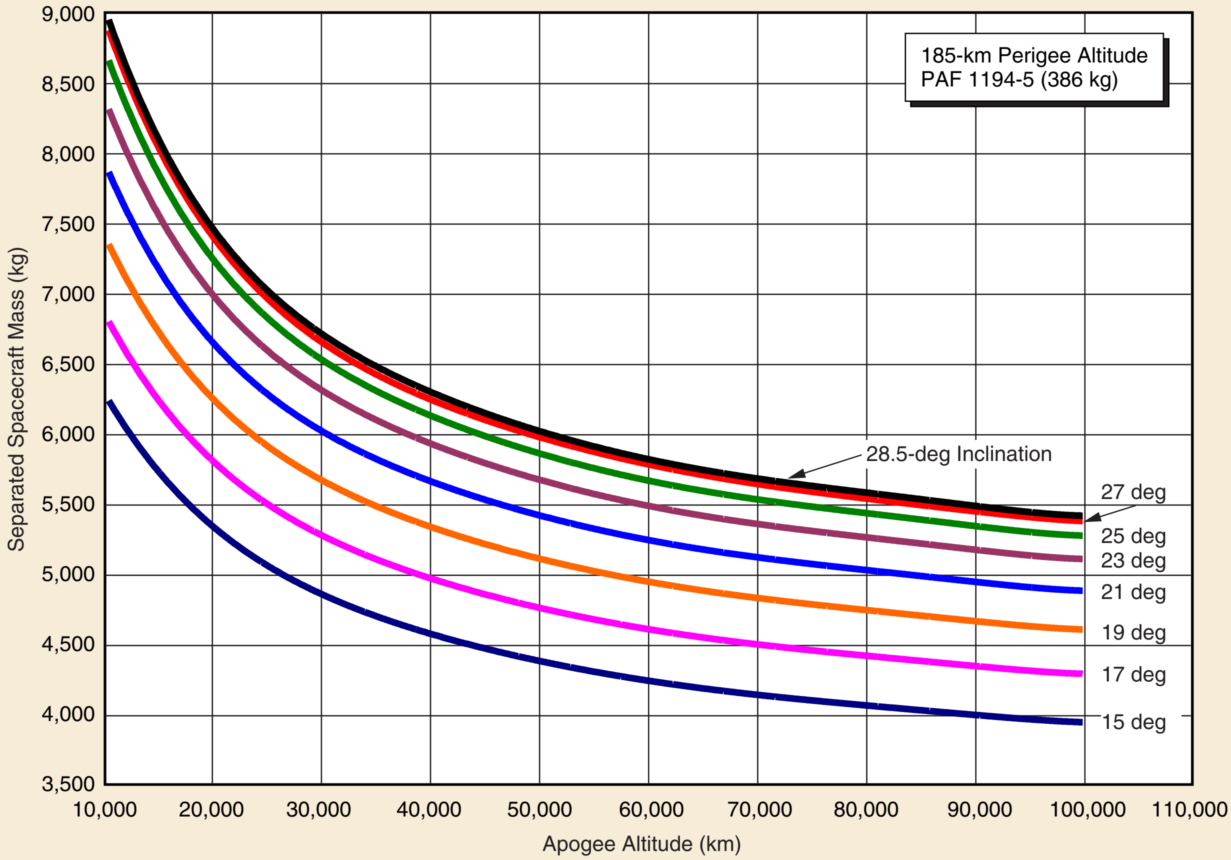



**Figure 2-26. Delta IV-M+ (5,2) LEO Excess ΔV Capability (Western Range)**

HB02116REU0.2

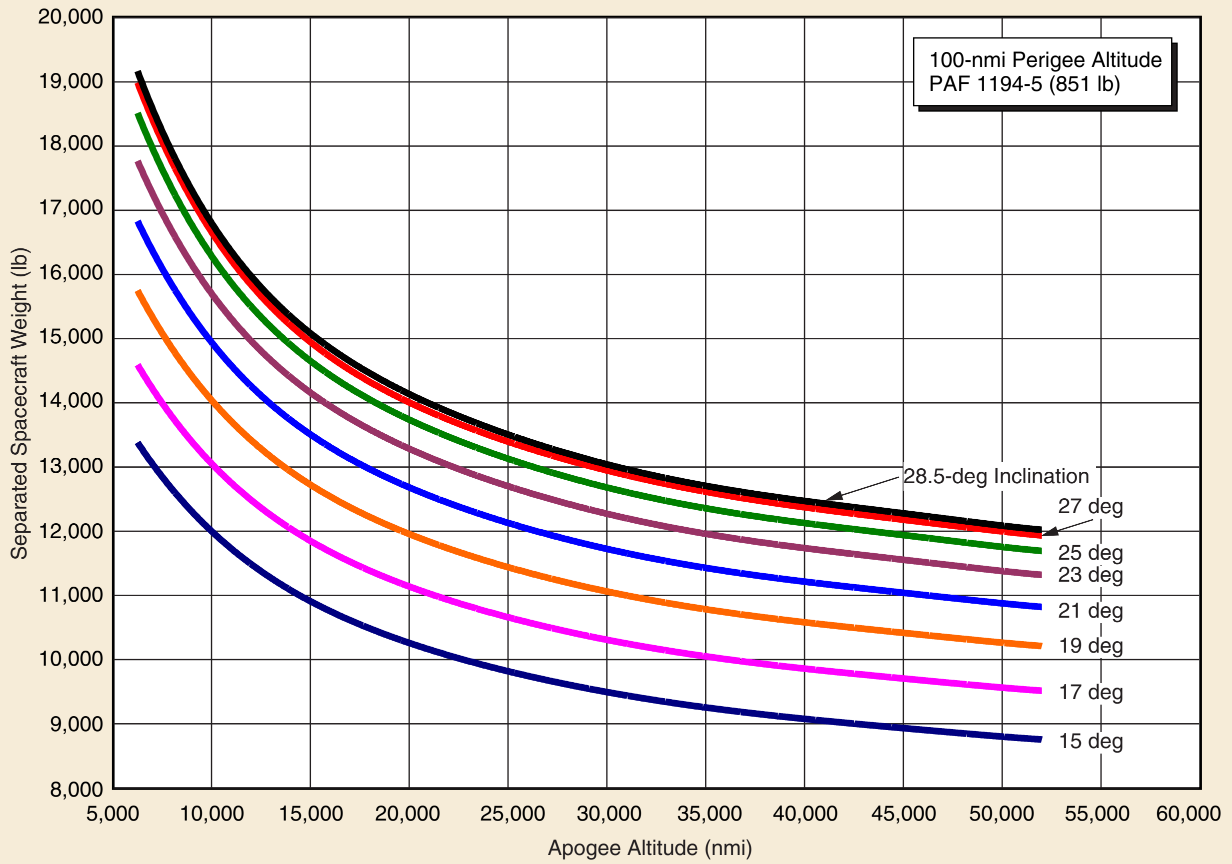



| Apogee Altitude (km)* | Separated Spacecraft Mass (kg) Inclination (deg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **10,000** | 8,940 | 8,854 | 8,631 | 8,277 | 7,834 | 7,327 | 6,789 | 6,227 |
| **15,000** | 8,042 | 7,975 | 7,788 | 7,498 | 7,126 | 6,689 | 6,215 | 5,712 |
| **20,000** | 7,435 | 7,373 | 7,214 | 6,962 | 6,632 | 6,240 | 5,808 | 5,346 |
| **25,000** | 7,018 | 6,956 | 6,817 | 6,587 | 6,284 | 5,920 | 5,515 | 5,081 |
| **30,000** | 6,722 | 6,661 | 6,532 | 6,316 | 6,030 | 5,685 | 5,299 | 4,883 |
| **35,786** | 6,470 | 6,411 | 6,289 | 6,084 | 5,810 | 5,480 | 5,109 | 4,709 |
| **40,000** | 6,325 | 6,269 | 6,149 | 5,948 | 5,682 | 5,360 | 4,998 | 4,607 |
| **45,000** | 6,179 | 6,128 | 6,008 | 5,813 | 5,554 | 5,241 | 4,887 | 4,505 |
| **50,000** | 6,054 | 6,008 | 5,888 | 5,698 | 5,445 | 5,139 | 4,793 | 4,419 |
| **55,000** | 5,949 | 5,906 | 5,785 | 5,600 | 5,353 | 5,053 | 4,713 | 4,345 |
| **60,000** | 5,859 | 5,818 | 5,699 | 5,518 | 5,275 | 4,980 | 4,645 | 4,282 |
| **65,000** | 5,786 | 5,745 | 5,628 | 5,449 | 5,209 | 4,918 | 4,587 | 4,228 |
| **70,000** | 5,725 | 5,683 | 5,569 | 5,392 | 5,155 | 4,867 | 4,539 | 4,183 |
| **71,572** | 5,709 | 5,665 | 5,553 | 5,376 | 5,139 | 4,852 | 4,525 | 4,170 |
| **75,000** | 5,674 | 5,630 | 5,519 | 5,343 | 5,108 | 4,822 | 4,497 | 4,144 |
| **80,000** | 5,627 | 5,582 | 5,474 | 5,299 | 5,065 | 4,782 | 4,459 | 4,108 |
| **85,000** | 5,581 | 5,537 | 5,429 | 5,256 | 5,024 | 4,743 | 4,423 | 4,075 |
| **90,000** | 5,534 | 5,492 | 5,384 | 5,213 | 4,984 | 4,706 | 4,388 | 4,043 |
| **95,000** | 5,491 | 5,451 | 5,342 | 5,173 | 4,947 | 4,672 | 4,357 | 4,013 |
| **100,000** | 5,465 | 5,423 | 5,316 | 5,148 | 4,922 | 4,648 | 4,334 | 3,991 |

*Note: Trajectories have a perigee altitude of 185 km

**Figure 2-27a. Delta IV-M+ (5,4) Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)**

HB02117REU0.1




| Apogee Altitude (nmi)* | Separated Spacecraft Weight (lb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **6,000** | 19,199 | 19,023 | 18,550 | 17,808 | 16,873 | 15,796 | 14,646 | 13,440 |
| **8,000** | 17,789 | 17,640 | 17,226 | 16,583 | 15,757 | 14,790 | 13,740 | 12,628 |
| **10,000** | 16,735 | 16,596 | 16,230 | 15,654 | 14,905 | 14,015 | 13,039 | 11,997 |
| **12,000** | 15,941 | 15,805 | 15,476 | 14,945 | 14,248 | 13,415 | 12,492 | 11,503 |
| **14,000** | 15,335 | 15,199 | 14,896 | 14,397 | 13,737 | 12,944 | 12,060 | 11,111 |
| **16,000** | 14,861 | 14,726 | 14,441 | 13,963 | 13,329 | 12,566 | 11,712 | 10,794 |
| **18,000** | 14,480 | 14,347 | 14,074 | 13,612 | 12,997 | 12,257 | 11,426 | 10,532 |
| **19,323** | 14,265 | 14,135 | 13,866 | 13,412 | 12,808 | 12,081 | 11,263 | 10,382 |
| **20,000** | 14,164 | 14,035 | 13,768 | 13,318 | 12,719 | 11,998 | 11,186 | 10,312 |
| **22,000** | 13,892 | 13,771 | 13,506 | 13,066 | 12,481 | 11,775 | 10,979 | 10,122 |
| **24,000** | 13,655 | 13,541 | 13,276 | 12,846 | 12,273 | 11,581 | 10,799 | 9,955 |
| **26,000** | 13,444 | 13,338 | 13,073 | 12,652 | 12,089 | 11,409 | 10,639 | 9,808 |
| **28,000** | 13,257 | 13,157 | 12,892 | 12,478 | 11,925 | 11,256 | 10,497 | 9,678 |
| **30,000** | 13,090 | 12,996 | 12,732 | 12,325 | 11,780 | 11,121 | 10,372 | 9,561 |
| **32,000** | 12,945 | 12,853 | 12,591 | 12,190 | 11,652 | 11,001 | 10,260 | 9,458 |
| **34,000** | 12,818 | 12,727 | 12,468 | 12,072 | 11,540 | 10,896 | 10,162 | 9,367 |
| **36,000** | 12,708 | 12,616 | 12,362 | 11,969 | 11,442 | 10,803 | 10,075 | 9,286 |
| **38,646** | 12,585 | 12,490 | 12,242 | 11,852 | 11,330 | 10,697 | 9,976 | 9,193 |
| **40,000** | 12,529 | 12,432 | 12,187 | 11,798 | 11,279 | 10,648 | 9,930 | 9,150 |
| **42,000** | 12,451 | 12,352 | 12,111 | 11,724 | 11,208 | 10,581 | 9,866 | 9,091 |
| **44,000** | 12,376 | 12,277 | 12,038 | 11,654 | 11,140 | 10,517 | 9,807 | 9,035 |
| **46,000** | 12,301 | 12,203 | 11,965 | 11,583 | 11,074 | 10,454 | 9,748 | 8,981 |
| **48,000** | 12,224 | 12,130 | 11,891 | 11,513 | 11,008 | 10,393 | 9,692 | 8,928 |
| **50,000** | 12,149 | 12,060 | 11,819 | 11,445 | 10,944 | 10,334 | 9,637 | 8,877 |
| **52,000** | 12,084 | 11,998 | 11,757 | 11,386 | 10,889 | 10,282 | 9,589 | 8,832 |

*Note: Trajectories have a perigee altitude of 100 nmi

**Figure 2-27b. Delta IV-M+ (5,4) Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)**

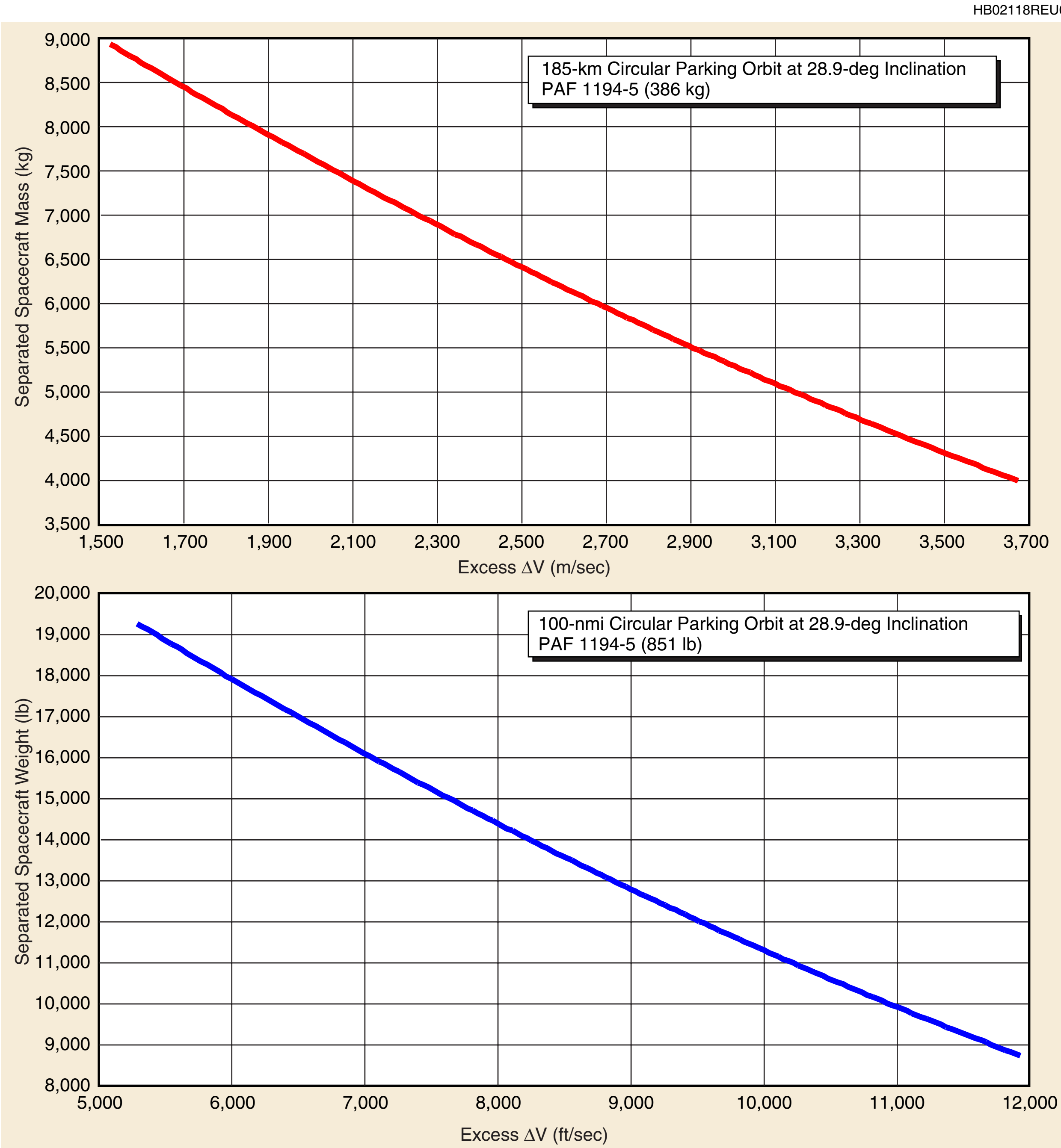



**Figure 2-28. Delta IV-M+ (5,4) GTO Excess ΔV Capability (Eastern Range)**

HB02119REU0

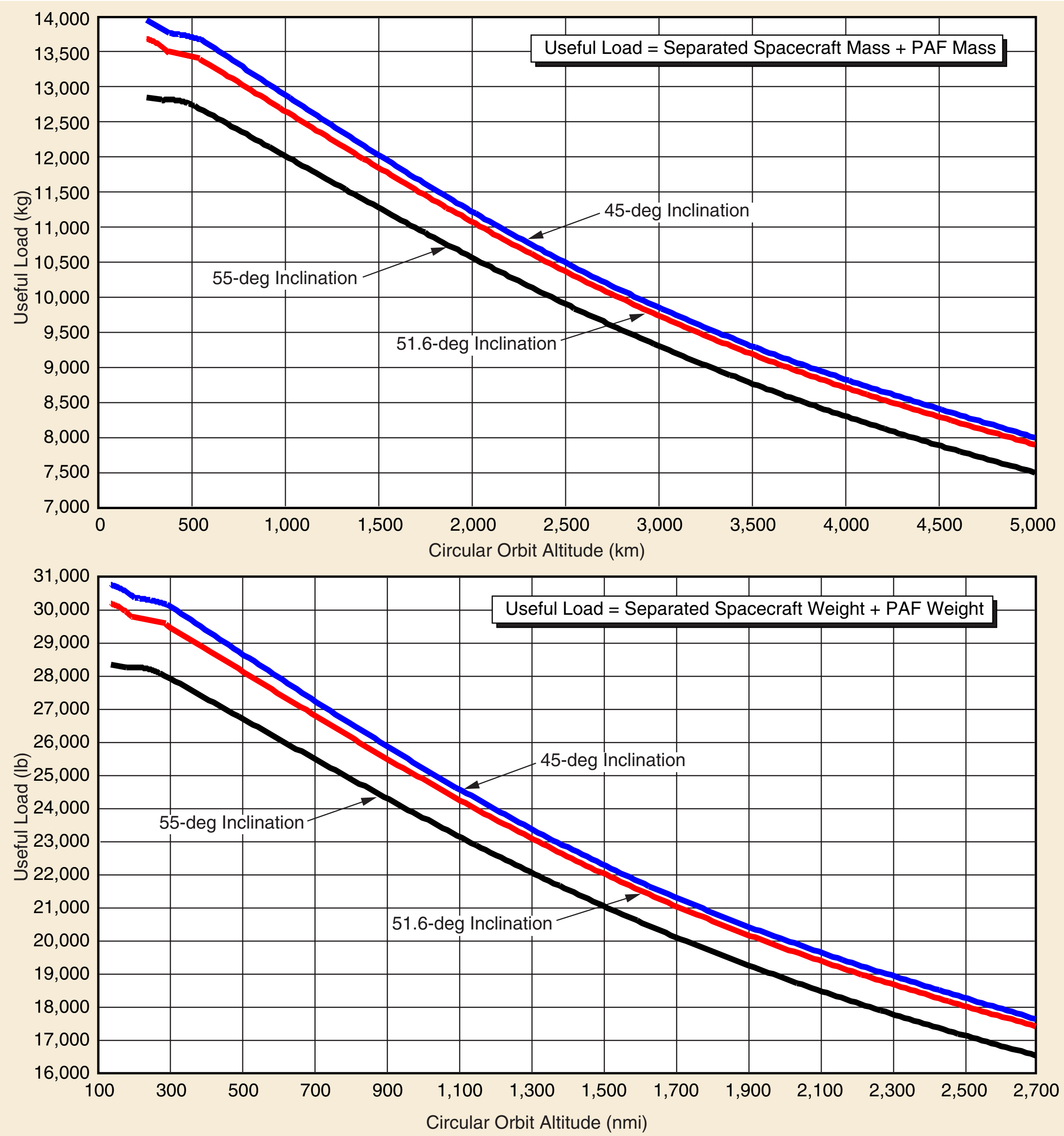



**Figure 2-29. Delta IV-M+ (5,4) LEO Circular Orbit Capability (Eastern Range)**

HB02120REU0

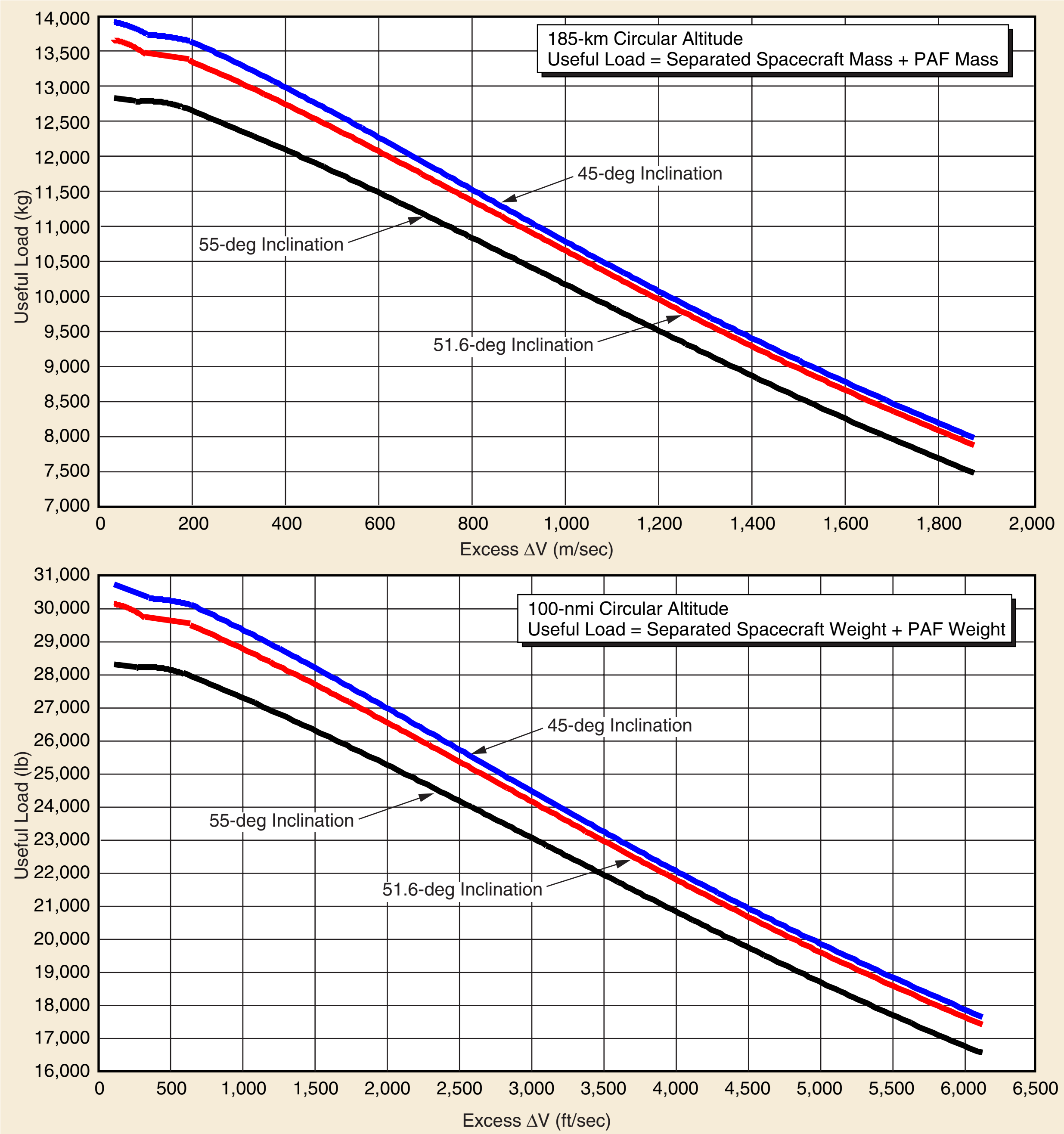



**Figure 2-30. Delta IV-M+ (5,4) LEO Excess ΔV Capability (Eastern Range)**

HB02121REU0

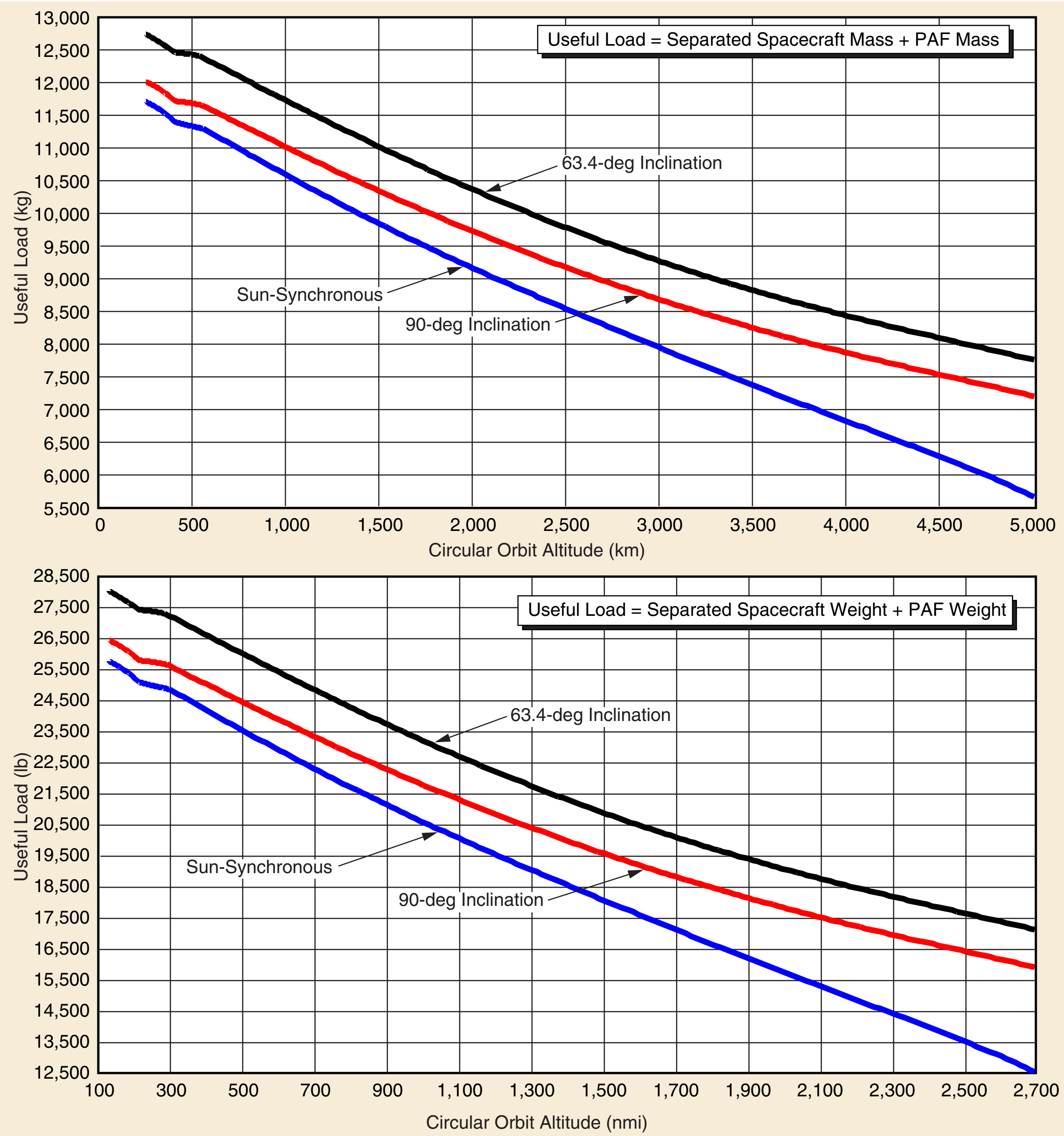



**Figure 2-31. Delta IV-M+ (5,4) LEO Circular Orbit Capability (Western Range)**

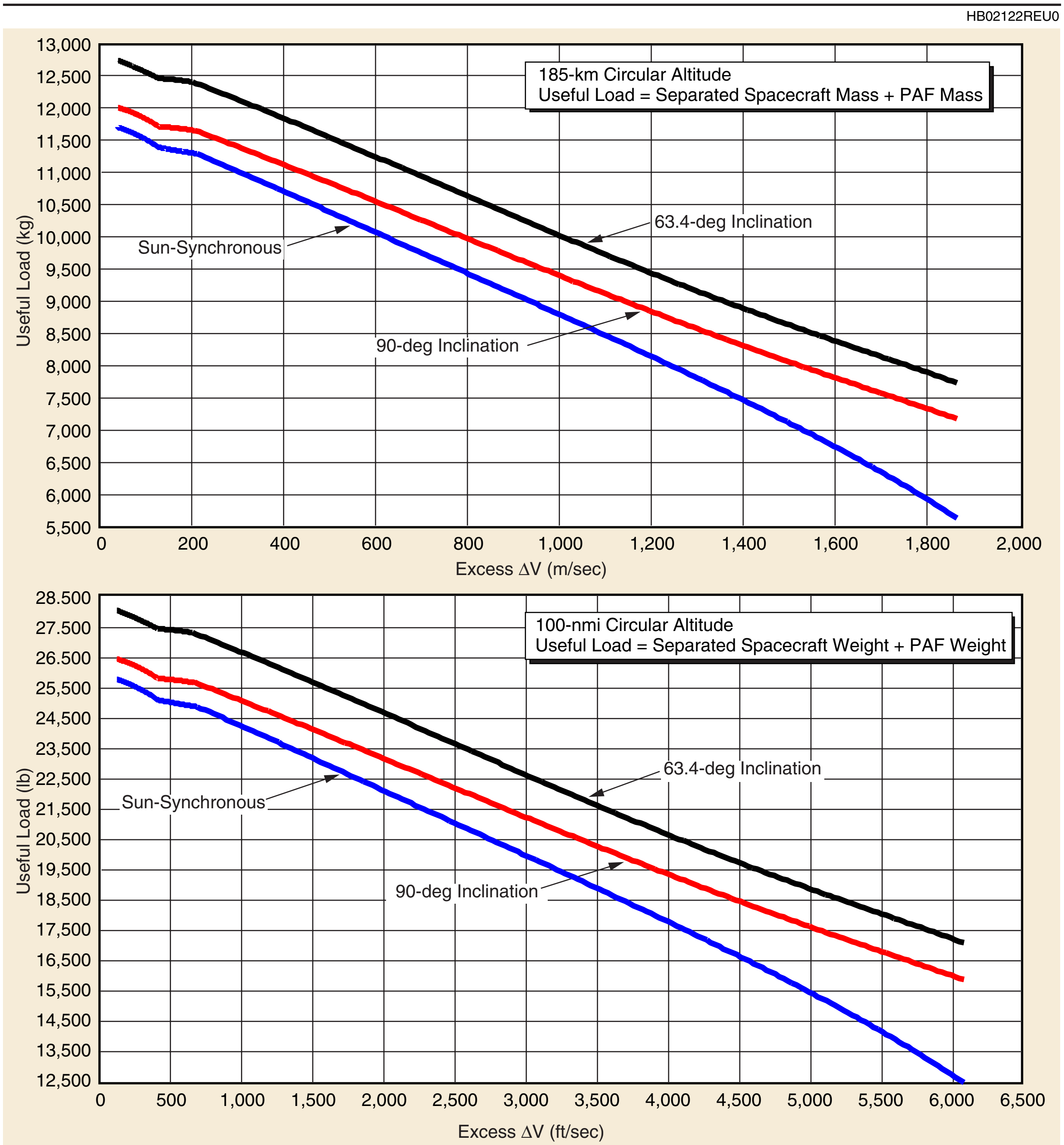
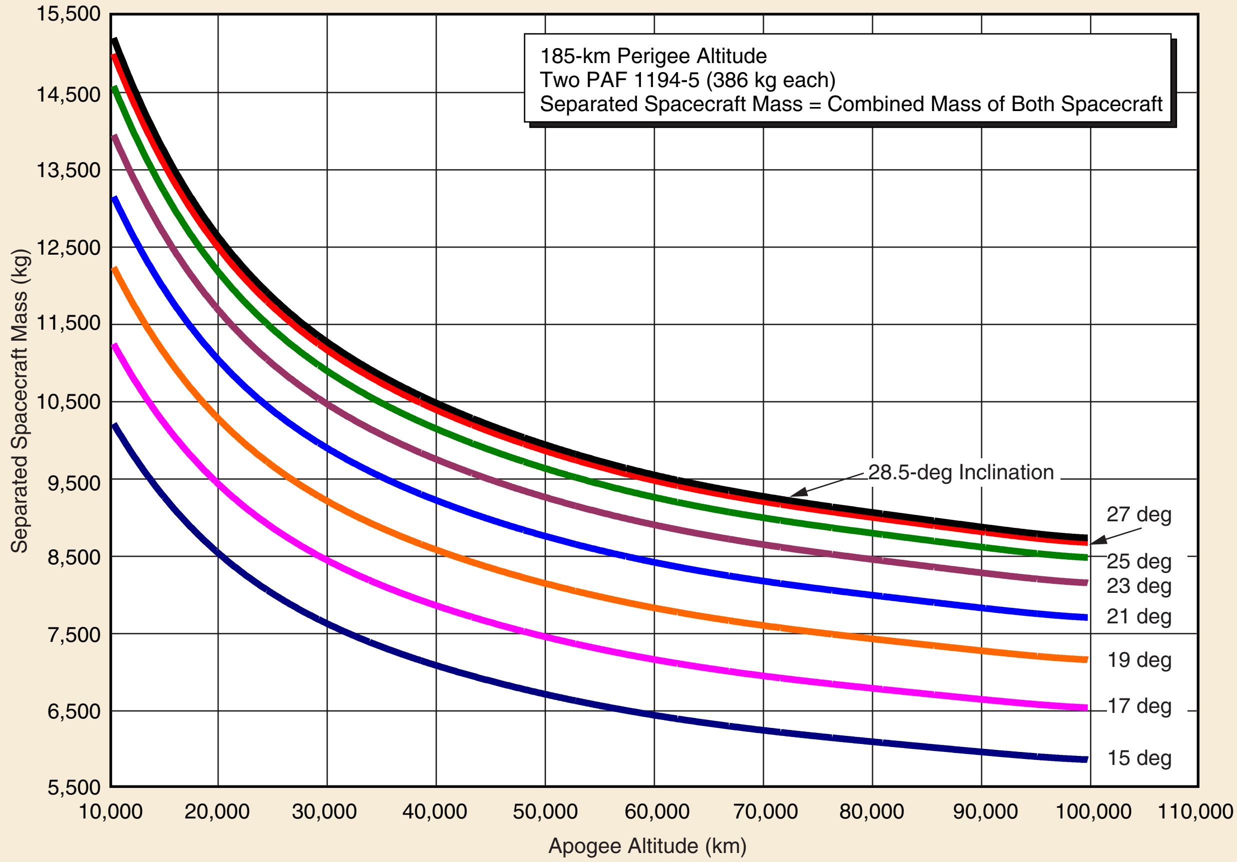



**Figure 2-32. Delta IV-M+ (5,4) LEO Excess ΔV Capability (Western Range)**

HB02123REU0.2




| Apogee Altitude (km)* | Separated Spacecraft Mass (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | **28.5** | **27** | **25** | **23** | **21** | **19** | **17** | **15** |
| **10,000** | 15,229 | 15,025 | 14,613 | 13,986 | 13,195 | 12,287 | 11,304 | 10,281 |
| **15,000** | 13,691 | 13,530 | 13,178 | 12,636 | 11,939 | 11,123 | 10,228 | 9,286 |
| **20,000** | 12,619 | 12,486 | 12,174 | 11,688 | 11,053 | 10,300 | 9,466 | 8,582 |
| **25,000** | 11,860 | 11,745 | 11,459 | 11,010 | 10,417 | 9,708 | 8,918 | 8,075 |
| **30,000** | 11,303 | 11,201 | 10,934 | 10,509 | 9,946 | 9,269 | 8,510 | 7,699 |
| **35,786** | 10,819 | 10,726 | 10,474 | 10,071 | 9,532 | 8,882 | 8,151 | 7,367 |
| **40,000** | 10,535 | 10,448 | 10,205 | 9,813 | 9,288 | 8,654 | 7,939 | 7,172 |
| **45,000** | 10,250 | 10,167 | 9,933 | 9,554 | 9,043 | 8,424 | 7,726 | 6,975 |
| **50,000** | 10,007 | 9,929 | 9,702 | 9,333 | 8,834 | 8,228 | 7,544 | 6,807 |
| **55,000** | 9,799 | 9,724 | 9,505 | 9,144 | 8,655 | 8,060 | 7,388 | 6,664 |
| **60,000** | 9,623 | 9,551 | 9,337 | 8,982 | 8,502 | 7,917 | 7,255 | 6,541 |
| **65,000** | 9,474 | 9,405 | 9,195 | 8,846 | 8,373 | 7,796 | 7,142 | 6,437 |
| **70,000** | 9,350 | 9,283 | 9,076 | 8,731 | 8,263 | 7,693 | 7,047 | 6,349 |
| **71,572** | 9,314 | 9,248 | 9,042 | 8,699 | 8,232 | 7,664 | 7,019 | 6,324 |
| **75,000** | 9,242 | 9,177 | 8,973 | 8,632 | 8,169 | 7,604 | 6,964 | 6,272 |
| **80,000** | 9,145 | 9,081 | 8,879 | 8,542 | 8,083 | 7,523 | 6,889 | 6,203 |
| **85,000** | 9,051 | 8,989 | 8,790 | 8,456 | 8,001 | 7,447 | 6,817 | 6,137 |
| **90,000** | 8,959 | 8,898 | 8,702 | 8,372 | 7,922 | 7,372 | 6,748 | 6,073 |
| **95,000** | 8,874 | 8,815 | 8,621 | 8,294 | 7,848 | 7,303 | 6,684 | 6,014 |
| **100,000** | 8,816 | 8,757 | 8,565 | 8,240 | 7,796 | 7,254 | 6,638 | 5,972 |

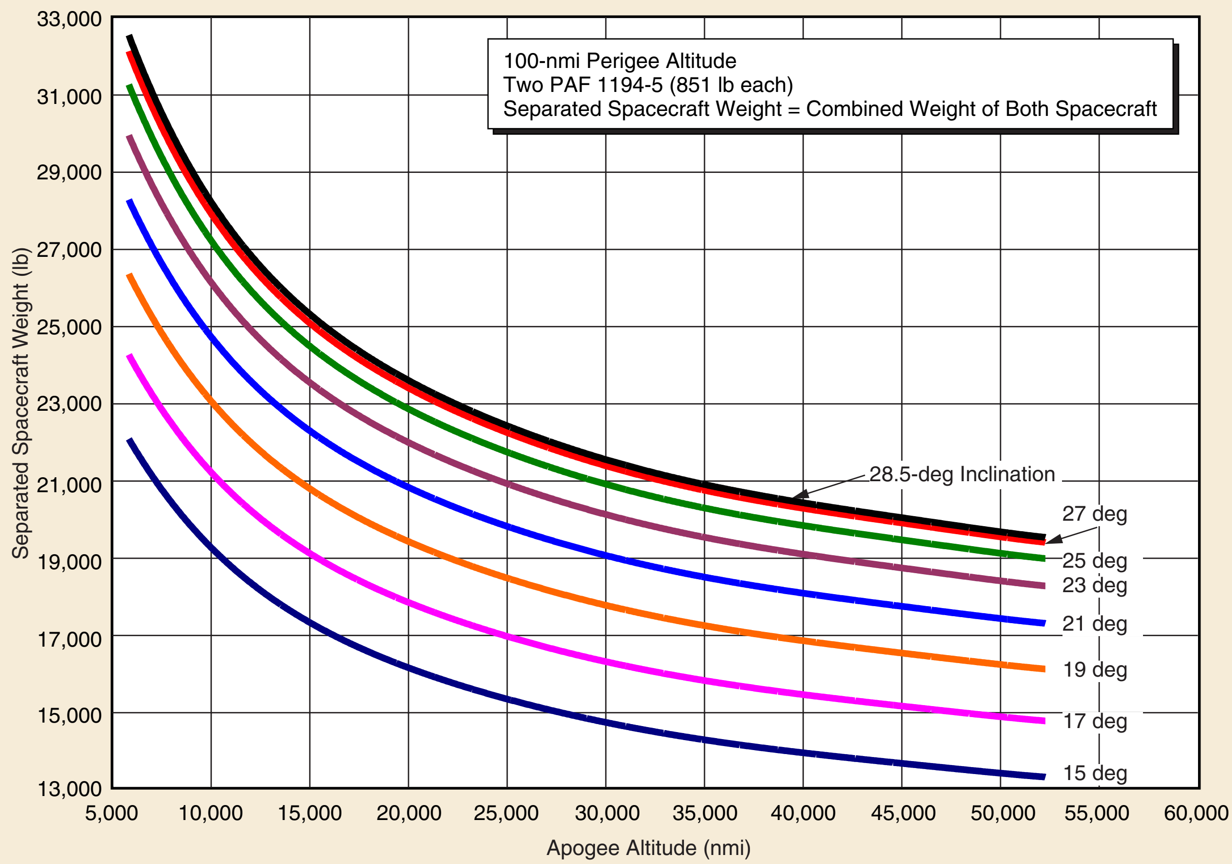
*Note: Trajectories have a perigee altitude of 185 km
**Note: Combined mass of both spacecraft

**Figure 2-33a. Delta IV-H Dual-Manifest Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)**



BOEING

HB02124REU0.1




| Apogee Altitude (nmi)* | Separated Spacecraft Weight (lb)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **6,000** | 32,710 | 32,285 | 31,411 | 30,078 | 28,386 | 26,438 | 24,319 | 22,109 |
| **8,000** | 30,288 | 29,929 | 29,151 | 27,950 | 26,406 | 24,602 | 22,622 | 20,540 |
| **10,000** | 28,436 | 28,126 | 27,417 | 26,313 | 24,877 | 23,183 | 21,309 | 19,326 |
| **12,000** | 27,007 | 26,734 | 26,075 | 25,043 | 23,688 | 22,077 | 20,285 | 18,380 |
| **14,000** | 25,890 | 25,643 | 25,022 | 24,043 | 22,749 | 21,202 | 19,474 | 17,631 |
| **16,000** | 24,998 | 24,771 | 24,179 | 23,241 | 21,994 | 20,497 | 18,820 | 17,027 |
| **18,000** | 24,268 | 24,056 | 23,487 | 22,580 | 21,371 | 19,914 | 18,279 | 16,528 |
| **19,323** | 23,851 | 23,647 | 23,091 | 22,202 | 21,014 | 19,580 | 17,969 | 16,242 |
| **20,000** | 23,654 | 23,454 | 22,904 | 22,024 | 20,845 | 19,422 | 17,822 | 16,107 |
| **22,000** | 23,125 | 22,935 | 22,402 | 21,543 | 20,391 | 18,997 | 17,428 | 15,742 |
| **24,000** | 22,661 | 22,479 | 21,961 | 21,121 | 19,992 | 18,624 | 17,081 | 15,422 |
| **26,000** | 22,250 | 22,074 | 21,569 | 20,747 | 19,637 | 18,292 | 16,772 | 15,138 |
| **28,000** | 21,883 | 21,714 | 21,220 | 20,413 | 19,321 | 17,996 | 16,498 | 14,884 |
| **30,000** | 21,556 | 21,393 | 20,910 | 20,115 | 19,040 | 17,732 | 16,253 | 14,658 |
| **32,000** | 21,268 | 21,109 | 20,634 | 19,852 | 18,790 | 17,498 | 16,035 | 14,457 |
| **34,000** | 21,013 | 20,859 | 20,392 | 19,619 | 18,569 | 17,290 | 15,842 | 14,280 |
| **36,000** | 20,790 | 20,640 | 20,179 | 19,414 | 18,374 | 17,107 | 15,672 | 14,123 |
| **38,646** | 20,535 | 20,388 | 19,934 | 19,178 | 18,149 | 16,896 | 15,475 | 13,941 |
| **40,000** | 20,417 | 20,273 | 19,821 | 19,069 | 18,046 | 16,798 | 15,384 | 13,858 |
| **42,000** | 20,255 | 20,113 | 19,665 | 18,918 | 17,902 | 16,663 | 15,259 | 13,742 |
| **44,000** | 20,100 | 19,960 | 19,516 | 18,775 | 17,766 | 16,535 | 15,139 | 13,632 |
| **46,000** | 19,947 | 19,810 | 19,370 | 18,635 | 17,633 | 16,410 | 15,023 | 13,525 |
| **48,000** | 19,796 | 19,661 | 19,226 | 18,497 | 17,502 | 16,288 | 14,909 | 13,420 |
| **50,000** | 19,650 | 19,518 | 19,088 | 18,365 | 17,377 | 16,170 | 14,800 | 13,319 |
| **52,000** | 19,523 | 19,392 | 18,966 | 18,248 | 17,266 | 16,066 | 14,703 | 13,230 |

*Note: Trajectories have a perigee altitude of 100 nmi
**Note: Combined weight of both spacecraft

**Figure 2-33b. Delta IV-H Dual-Manifest Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)**

HB02125REU0

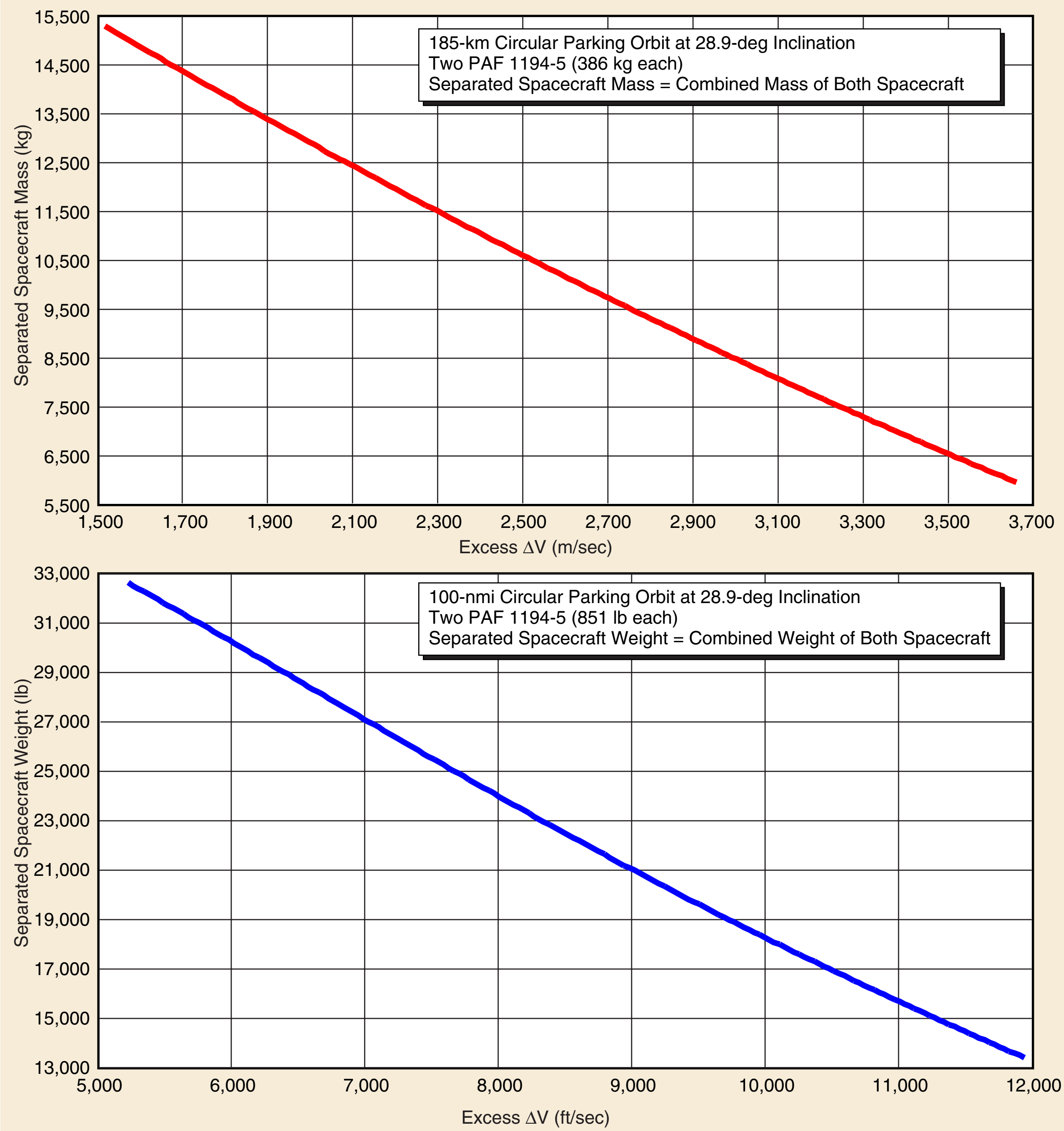



**Figure 2-34. Delta IV-H Dual-Manifest GTO Excess ΔV Capability (Eastern Range)**

HB02126REU0

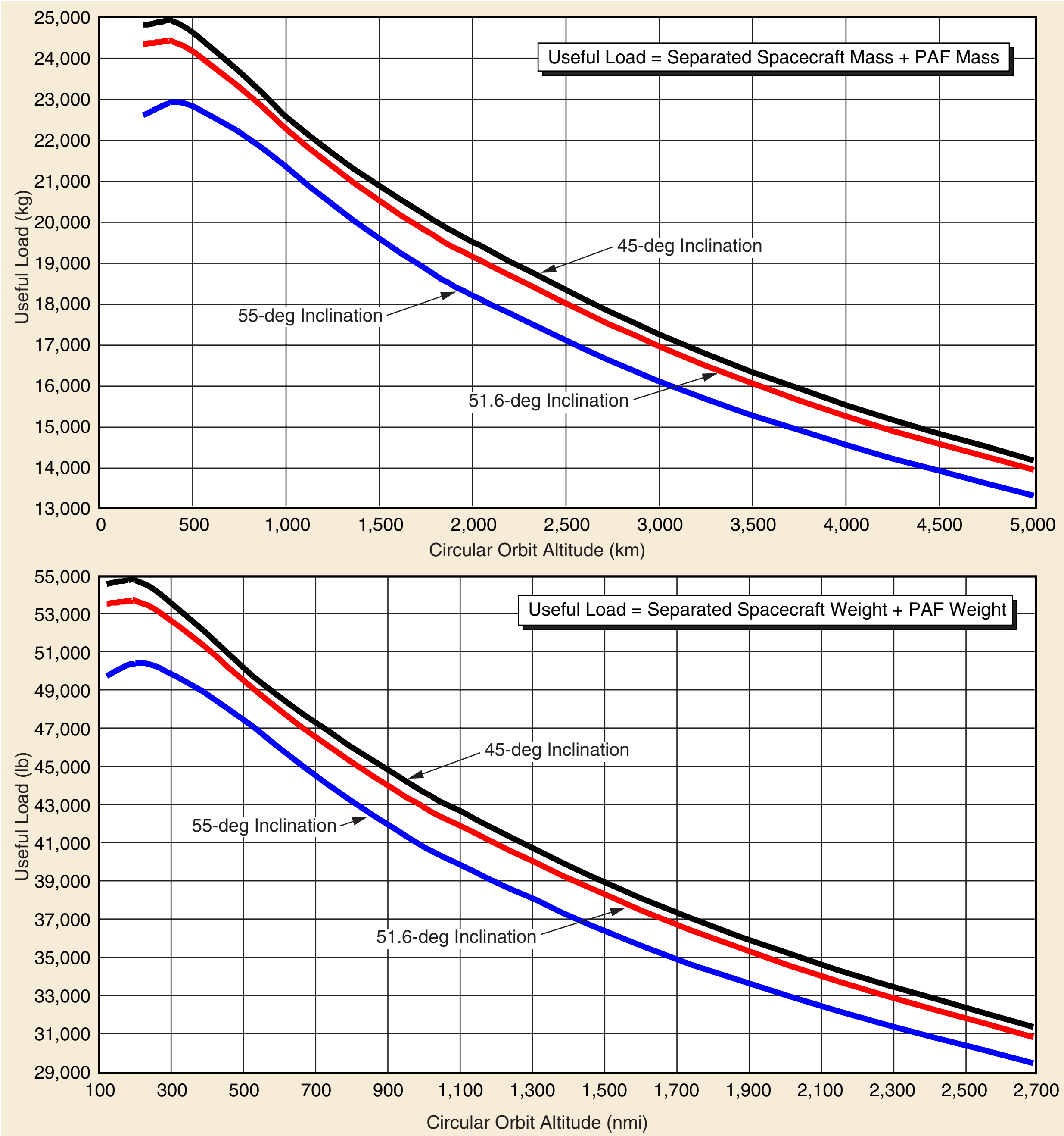



**Figure 2-35. Delta IV-H LEO Circular Orbit Capability (Eastern Range)**

HB02127REU0

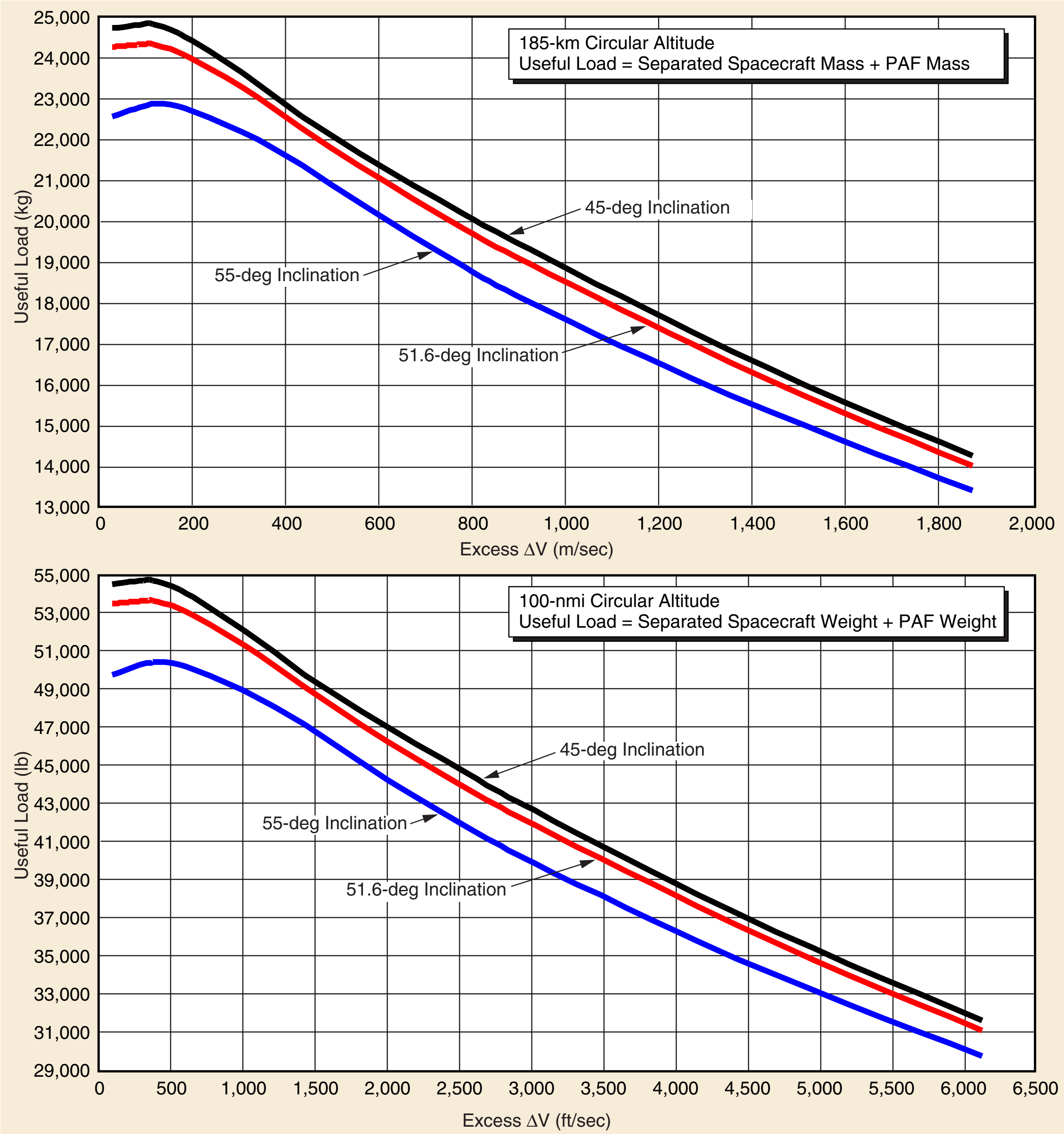



**Figure 2-36. Delta IV-H LEO Excess ΔV Capability (Eastern Range)**

HB02128REU0

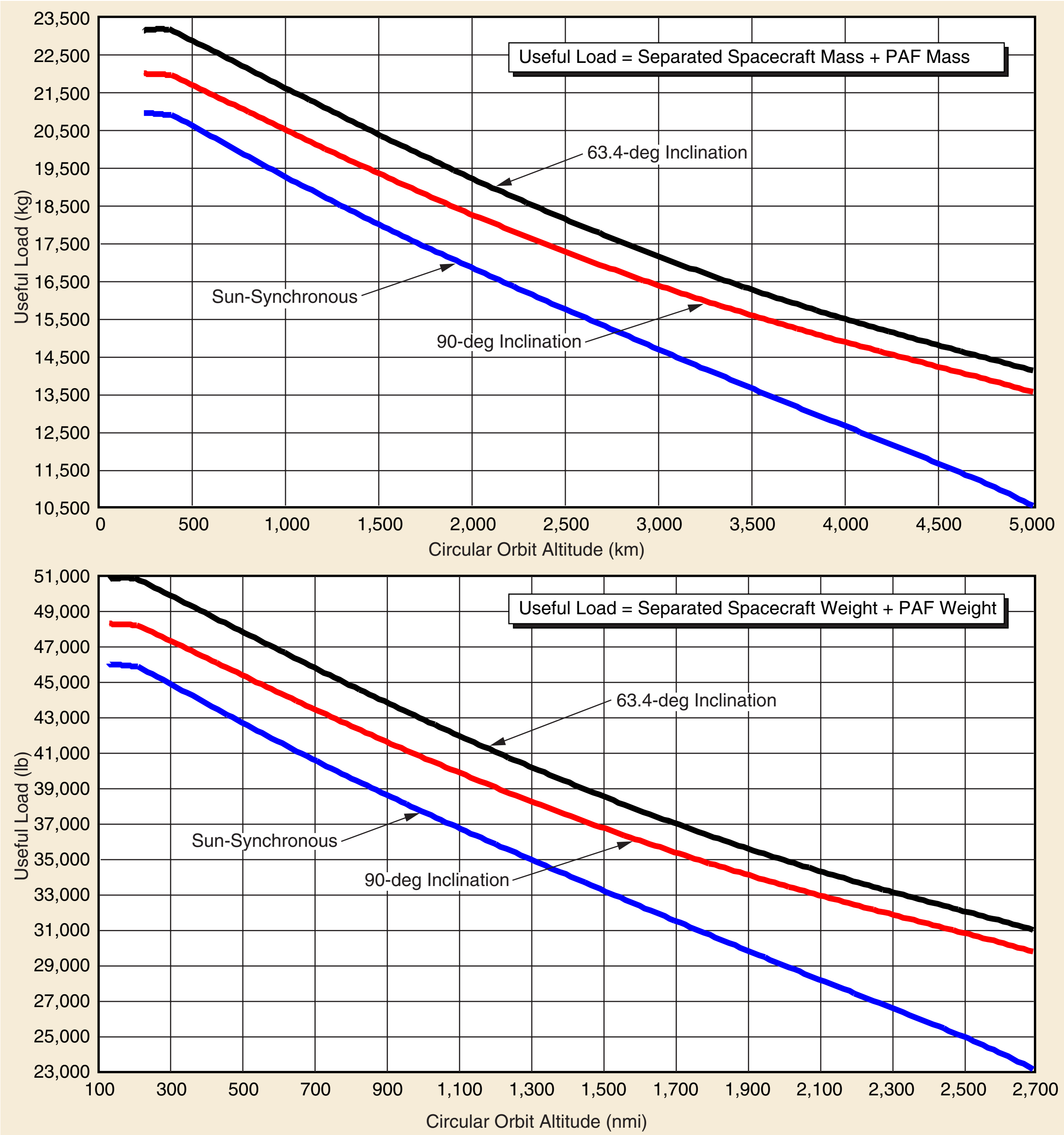



**Figure 2-37. Delta IV-H LEO Circular Orbit Capability (Western Range)**

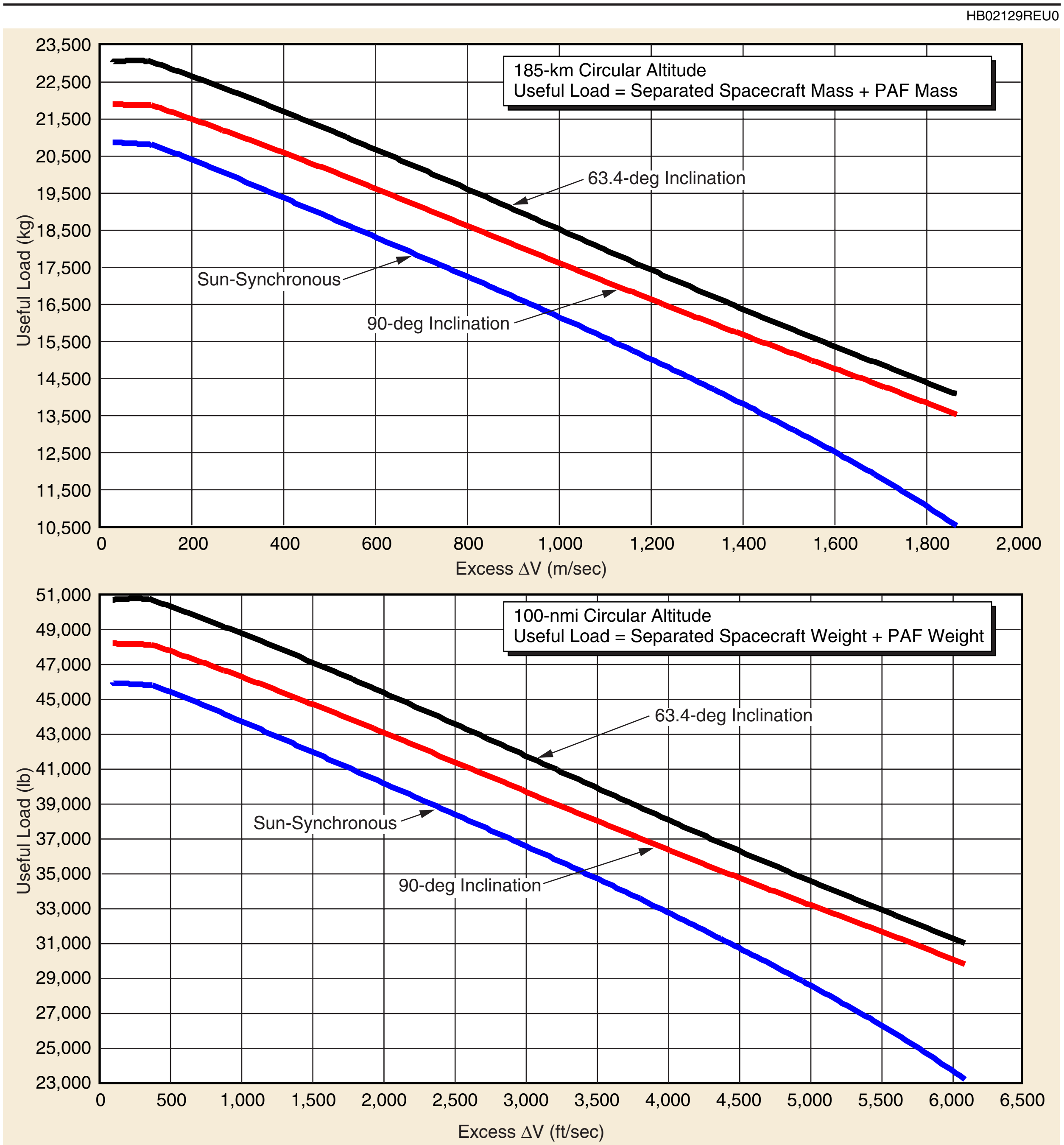



**Figure 2-38. Delta IV-H LEO Excess ΔV Capability (Western Range)**

# Section 3
# PAYLOAD FAIRINGS

The payload launched on a Delta IV Medium, Delta IV Medium-Plus, or Delta IV Heavy launch vehicle is protected by fairings that shield it from the external environment and contamination during the prelaunch and ascent phases. The Delta IV launch system uses a wide variety of heritage-based fairings to meet the broad needs of our customers (Figure 3-1). Fairings are jettisoned early during either first- or second-stage powered flight when an acceptable free molecular heating rate is reached (Section 2.3). A general discussion of the Delta IV fairings is presented in Section 3.1. Detailed fairing descriptions and envelopes are given in Sections 3.2 and 3.3.

## 3.1 GENERAL DESCRIPTION

The internal fairing envelopes presented in the following text and figures define the maximum allowable static dimensions of the payload (including manufacturing tolerances) relative to the payload/attach fitting interface. If the payload dimensions are maintained within these envelopes, there will be no contact of the payload with the fairing during flight as long as the payload's frequency and structural stiffness characteristics are within the guidelines specified in Section 4.2.3.2. Payload envelopes include allowances for relative deflections between the launch vehicle and payload. Also included are launch vehicle manufacturing tolerances and the thickness (including billowing) of the acoustic blankets that are installed on the interior of the fairing. Typical acoustic blanket configurations are described in Table 3-1.

Clearance layouts and analyses are performed and, if necessary, critical clearances between the payload and fairing are measured after the fairing is installed to ensure positive clearance during flight. To facilitate this, the payload description must include an accurate definition of the physical location of all points on the payload that are within 51 mm (2 in.) of the allowable envelope. (Refer to Section 8, Payload Integration.) The dimensions must include the maximum payload manufacturing tolerances (and, if applicable, blanket billowing).

An air-conditioning inlet door on the fairing provides a controlled environment for the encapsulated payload while on the launch stand (Section 4.1.1). A $GN_2$ purge system can be incorporated to provide continuous dry nitrogen to the payload until liftoff.

Payload contamination is minimized by cleaning the fairing in a class 100,000 cleanroom prior to shipment to the field site. More stringent cleanliness levels for the fairing and inspection using an ultraviolet (UV) light are available on request. (See Table 4-4 and Section 4.1.5 for a description of cleanliness levels.)

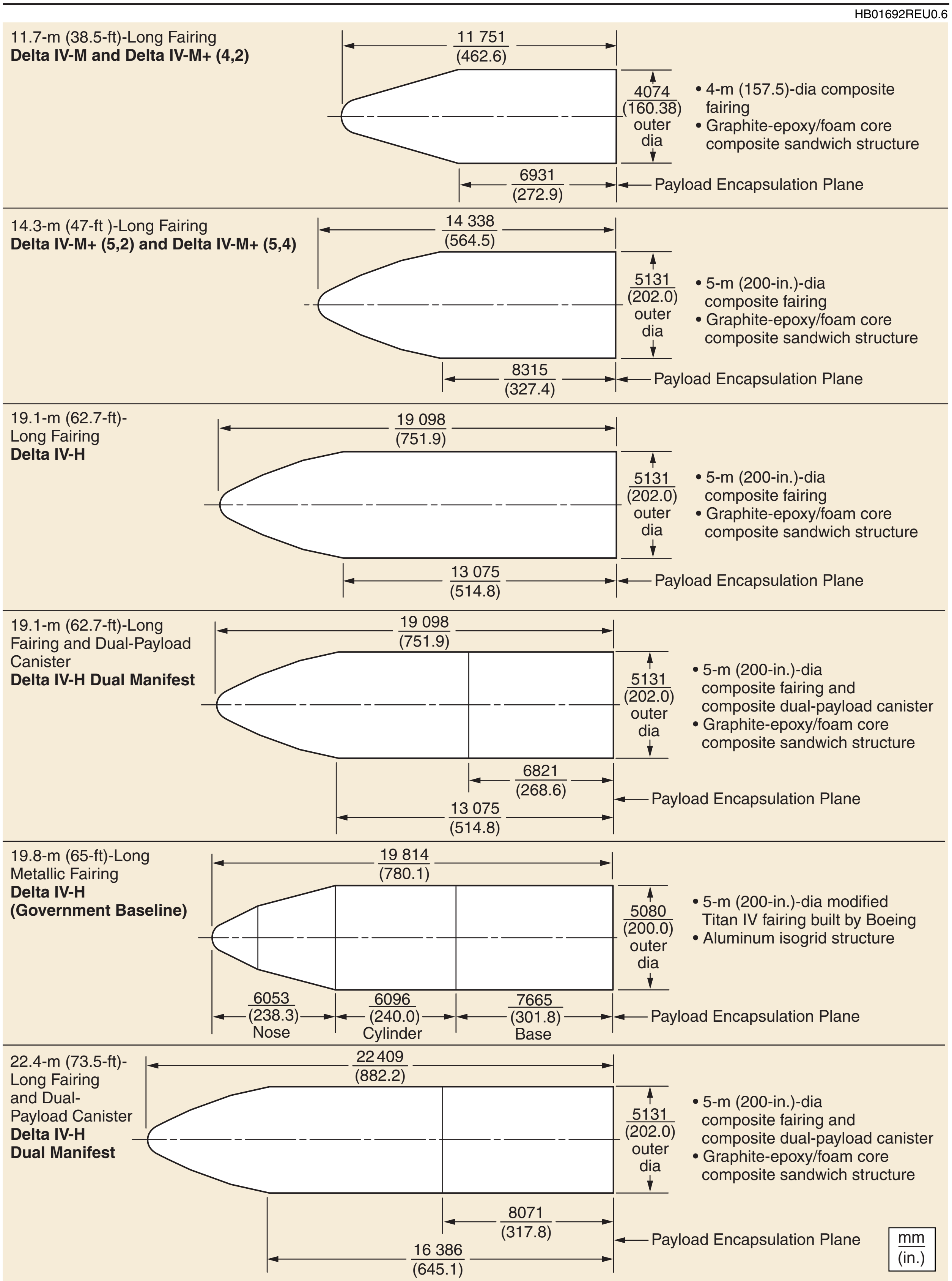



**Figure 3-1. Delta IV Fairing Configurations**

**Table 3-1. Typical Acoustic Blanket Configurations**

| Fairing | Location |
|---|---|
| 4-m Delta IV-M and Delta IV-M+ (4,2) | The baseline configuration for acoustic blankets is 76-mm (3-in.)-thick. |
| 5-m Delta IV-M+ (5,2), Delta IV-M+ (5,4), and Delta IV-H composite fairing | The baseline configuration for acoustic blankets is 114-mm (4.5-in.)-thick, running from just below the nose cap to the base of the fairing. |
| 5-m Delta IV-H, metallic fairing | The baseline configuration for acoustic blankets is 76-mm (3-in.)-thick, running from just below the 15-deg to 25-deg cone joint in the nose cone to the base of the fairing. |
| ■ The configurations may be modified to meet mission-specific requirements. | |
| ■ Blankets for the Delta IV composite fairings are constructed of acoustic dampening material and are vented through the aft section of the fairings. These blankets are designed to meet the intent of the 1.0% maximum total weight loss and 0.10% maximum volatile condensable material. | |
| ■ Blankets for the Delta IV metallic fairing are constructed of silicone-bonded heat-treated glass-fiber batting enclosed between two 0.076-mm (0.003-in.) conductive Teflon-impregnated fiberglass facesheets. The blankets are vented through a 5-µm stainless steel mesh filter that controls particulate contamination to levels better than a class 10,000 clean-room environment. Outgassing of the acoustic blankets meets the criteria of 1.0% maximum total weight loss and 0.10% maximum volatile condensable material. | |

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## 3.2 4-M AND 5-M-DIA COMPOSITE PAYLOAD FAIRING

The 4-m-dia by 11.7-m (38.5-ft)-long composite fairing is used on the Delta IV-M and Delta IV-M+ (4,2) launch vehicles. The 5-m-dia by 14.3-m (47-ft)-long composite fairing is used on the Delta IV-M+ (5,2) and Delta IV-M+ (5,4) launch vehicles. The 5-m-dia by 19.1-m (62.7-ft)-long composite fairing is used on the Delta IV-H commercial launch vehicle. Dual-manifest missions may utilize either a 5-m-dia by 19.1-m (62.7-ft)-long or 5-m-dia by 22.4-m (73.5-ft)-long fairing and dual-payload canister (DPC) on the Delta IV-H commercial launch vehicle.

The 4-m composite fairing (Figures 3-2 and 3-3) and the 5-m composite fairing (Figures 3-4 and 3-5) are composite sandwich structures that separate into two bisectors. Each bisector is constructed in a single co-cured layup, eliminating the need for module-to-module manufacturing joints and intermediate ring stiffeners. The resulting smooth inside skin provides the flexibility to install access doors almost anywhere in the cylindrical portion of the fairing (Figures 3-6, 3-7, and 3-8).

The allowable static payload envelope in the fairing is shown in Figure 3-2 for the 4-m composite fairing with the 1575-4 payload attach fitting (PAF) interface. Figure 3-3 defines the envelopes for the 4-m fairing with the 937-4, 1194-4, 1664-4, and 1666-4 payload attach fittings. Figures 3-4 and 3-5 define the envelopes for the 14.3-m (47-ft) and 19.1-m (62.7-ft)-long 5-m composite fairings with the 937-5, 1194-5, 1575-5, 1664-5, and 1666-5 payload attach fittings.

These figures assume that the payload stiffness guidelines in Section 4.2.3 are observed. All payload extrusions outside of the payload envelopes or below the payload separation plane require coordination with and approval of Delta Launch Services.

Two standard access doors, 0.46-m (18-in.) dia or 0.61-m (24-in.) dia, are provided in the fairing cylindrical section. Because it is understood that customers may need access to items such as payload ordnance devices, electrical connectors, and fill-and-drain valves for payloads using liquid propellants, additional access doors can be installed on a mission-unique basis. Also,

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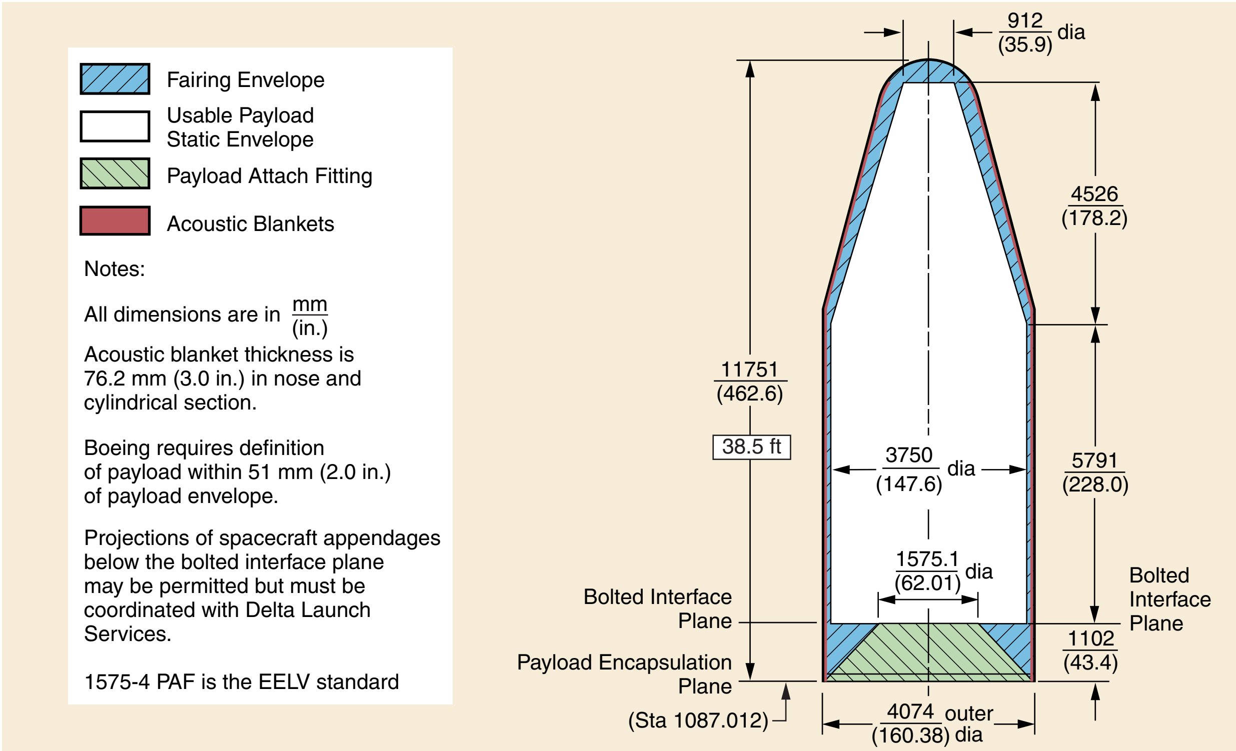


**Figure 3-2. Payload Envelope, 4-m-dia Composite Fairing—1575-4 PAF**

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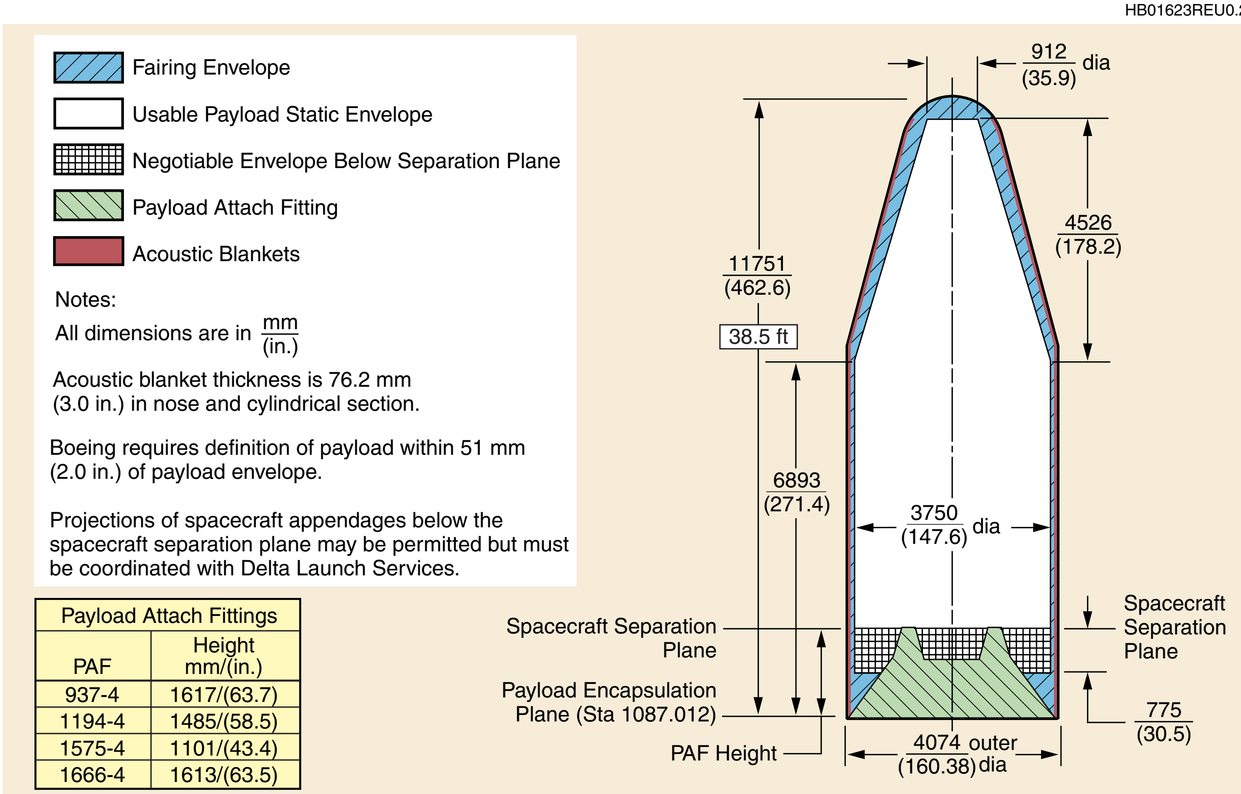


| Payload Attach Fittings | |
|---|---|
| PAF | Height mm/(in.) |
| 937-4 | 1617/(63.7) |
| 1194-4 | 1485/(58.5) |
| 1575-4 | 1101/(43.4) |
| 1666-4 | 1613/(63.5) |

**Figure 3-3. Payload Envelope, 4-m-dia Composite Fairing**

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- Fairing Envelope
- Usable Payload Static Envelope
- Negotiable Envelope Below Separation Plane
- Acoustic Blankets

Notes:

All dimensions are in $\frac{\text{mm}}{\text{(in.)}}$

Acoustic blanket thickness is 114.3 mm (4.5 in.) in nose and cylindrical section.

Boeing requires definition of payload within 51 mm (2.0 in.) of payload envelope.

Projections of spacecraft appendages below the spacecraft separation plane may be permitted but must be coordinated with Delta Launch Services.

| Payload Attach Fittings | |
|---|---|
| PAF | Height mm/(in.) |
| 937-5 | 2283/(89.9) |
| 1194-5 | 2088/(82.2) |
| 1575-5 | 1801/(70.9) |
| 1664-5 | 2121/(83.5) |
| 1666-5 | 2134/(84.0) |

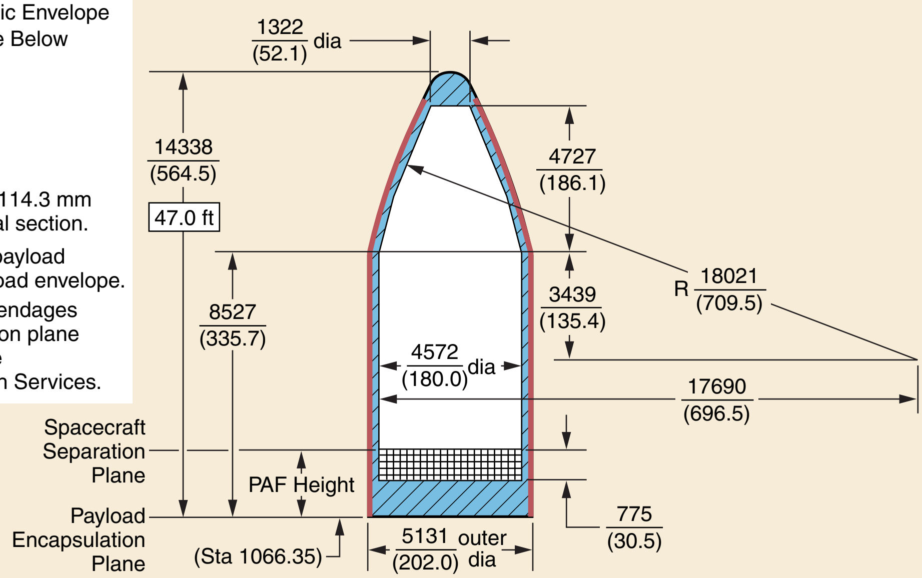


**Figure 3-4. Delta IV Medium-Plus 5-m-dia by 14.3-m-Long Composite Fairing Payload Envelope**

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- Fairing Envelope
- Usable Payload Static Envelope
- Negotiable Envelope Below Separation Plane
- Acoustic Blankets

Notes:

All dimensions are in $\frac{\text{mm}}{\text{(in.)}}$

Boeing requires definition of payload within 51 mm (2.0 in.) of payload envelope.

Acoustic blanket thickness is 114.3 mm (4.5 in.) in nose and cylindrical section.

Projections of spacecraft appendages below the payload separation plane may be permitted but must be coordinated with Delta Launch Services.

| Payload Attach Fittings | |
|---|---|
| PAF | Height mm/(in.) |
| 937-5 | 2283/(89.9) |
| 1194-5 | 2088/(82.2) |
| 1575-5 | 1801/(70.9) |
| 1664-5 | 2121/(83.5) |
| 1666-5 | 2134/(84.0) |

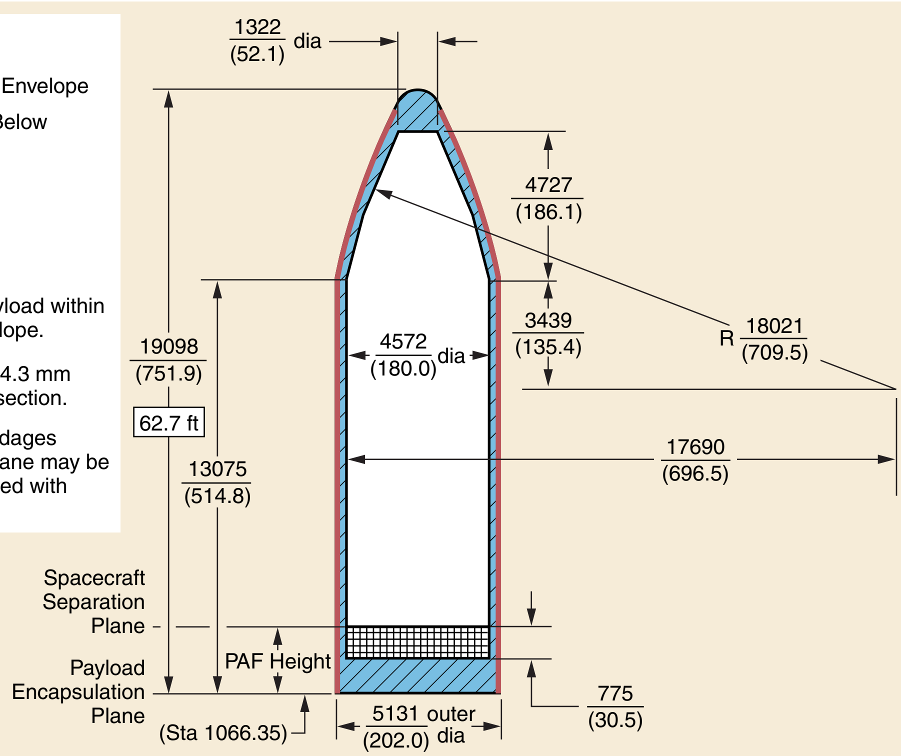


**Figure 3-5. Delta IV Heavy 5-m-dia by 19.1-m Composite Fairing Payload Envelope**

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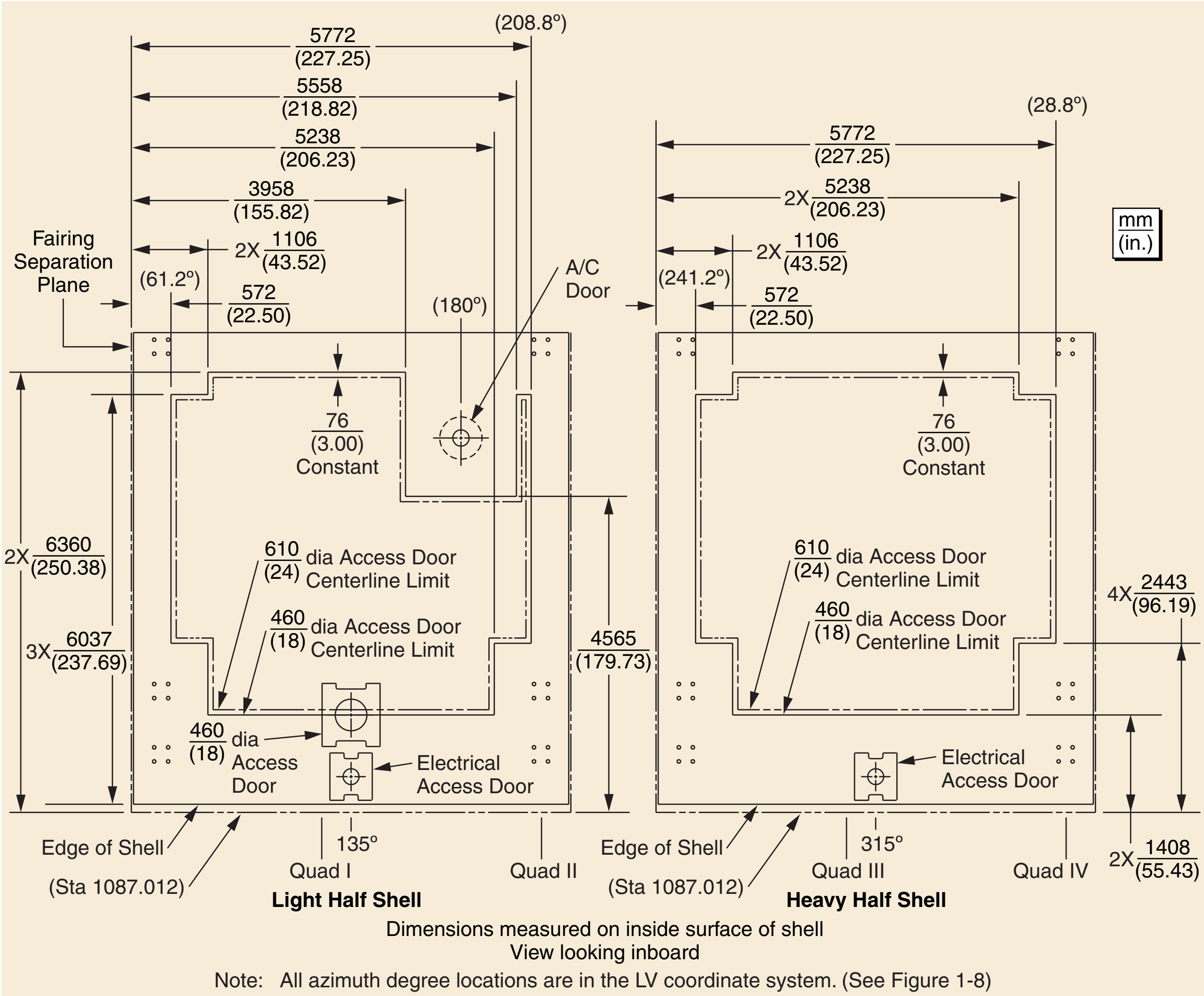


**Figure 3-6. Allowable Access Door Locations for 4-m-dia by 11.7-m-Long Composite Fairing**

differing diameters or shapes for the two standard access doors can be accommodated on a mission-unique basis. Access doors typically do not have acoustic blankets attached to their inboard surfaces but can have them, on a mission-unique basis, to provide additional acoustic attenuation. Access door locations and sizes should be coordinated with Delta Launch Services.

Radio frequency (RF) windows can be accommodated by co-curing during the shell layup or by post-curing later in the manufacturing cycle. RF window requirements should be coordinated with Delta Launch Services.

The bisectors are joined by a contamination-free linear piston/cylinder thrusting separation rail system that runs the full length of the fairing. Two functionally redundant explosive bolt assemblies provide structural continuity at the base ring of the fairing.

The fairing bisectors are jettisoned by actuating the explosive bolt assemblies and then detonating the linear explosive strands in the thrusting joint cylinder rail cavity. Separation

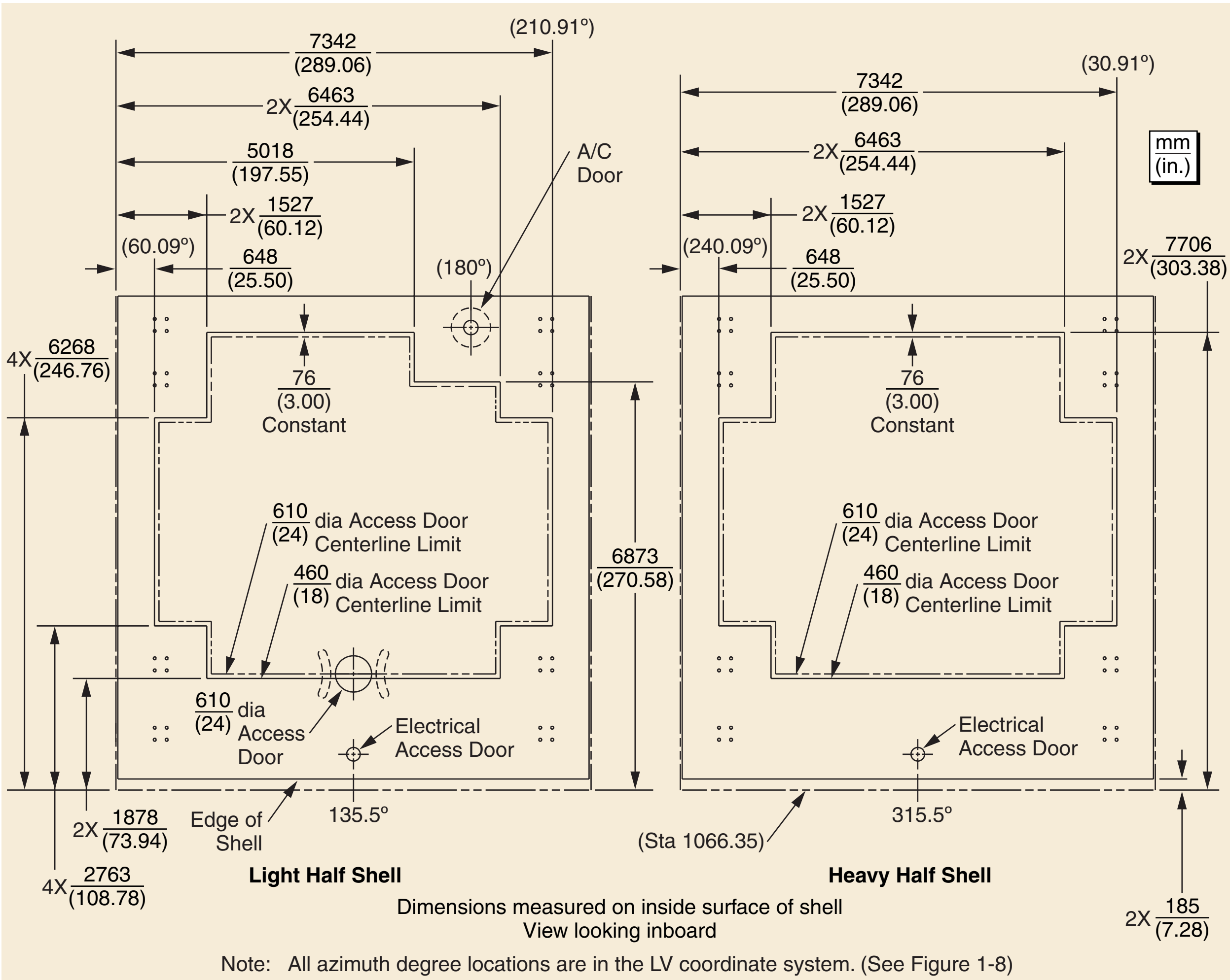


**Figure 3-7. Allowable Access Door Locations for 5-m-dia by 14.3-m-Long Composite Fairing**

augmentation springs are provided to ensure positive separation clearance. A bellows assembly in each cylinder rail retains the combustion product gases and thereby prevents payload contamination during the fairing separation event.

The dual-manifest concepts shown in Figures 3-9 and 3-10 feature a cylindrical composite dual-payload canister (DPC) that encapsulates the lower payload and a composite bisector fairing that encapsulates the upper payload. Both payloads are mounted within these bays to Delta IV separation interfaces, dependent on payload needs. These figures also assume that the payload stiffness guidelines in Section 4.2.3 are observed. Protrusion outside any portion of the payload envelope or below the payload separation plane require coordination with and approval of Delta Launch Services.

## 3.3 5-M-DIA METALLIC PAYLOAD FAIRING

The 5-m-dia modified Titan IV metallic fairing built by Boeing (Figure 3-11) is an aluminum isogrid structure that separates into three sectors. Its flight-proven, frame-stabilized isogrid skin is

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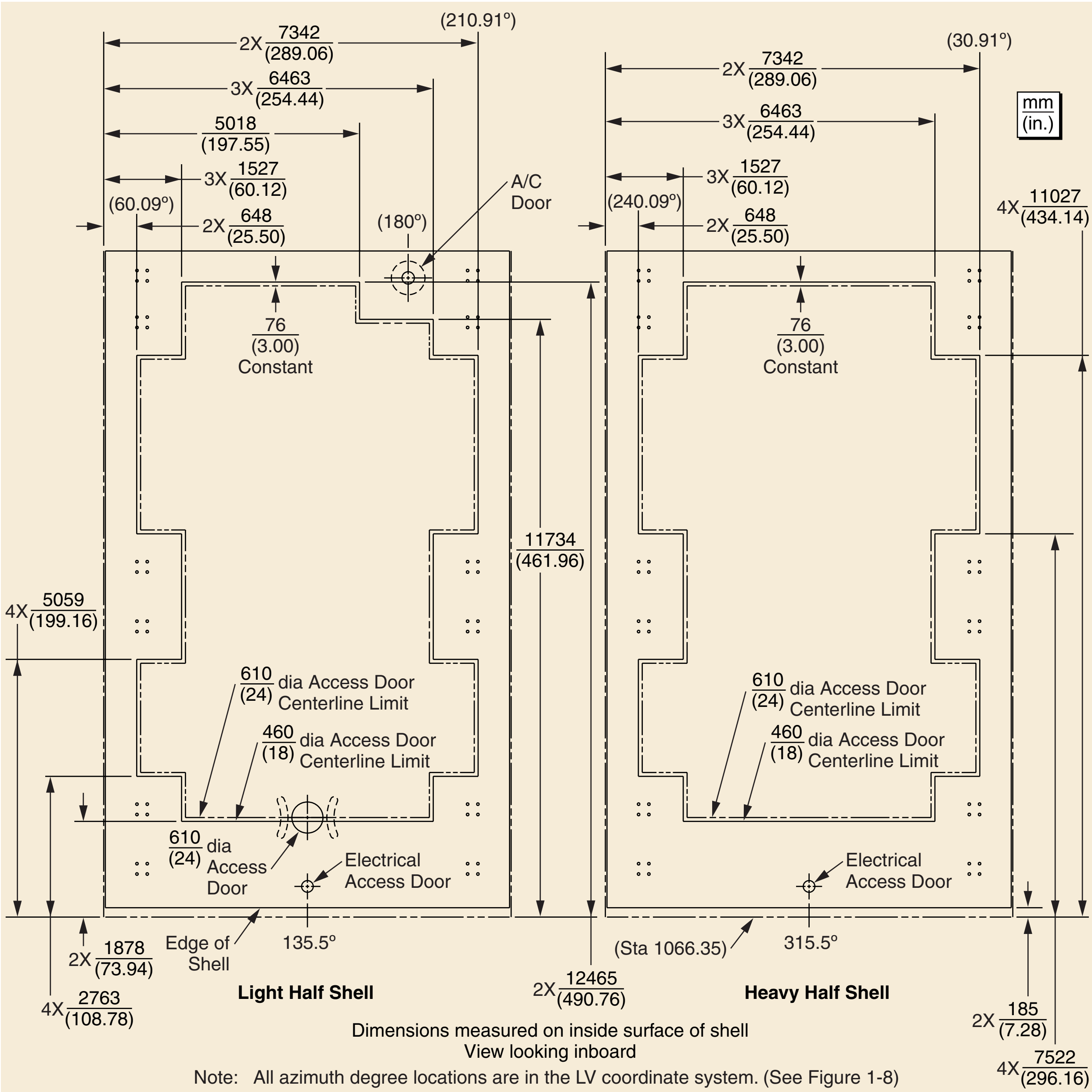


**Figure 3-8. Allowable Access Door Locations for 5-m-dia by 19.1-m-Long Composite Fairing**

designed to provide a lightweight structure while maintaining sufficient strength, stiffness, and aerial density, to withstand the flight environments. This fairing is 19.8 m (65 ft) long and is the baseline 5-m fairing for government Delta IV-H launch vehicles.

The PLF trisectors are joined by a contamination-free linear piston/cylinder thrusting separation rail system that runs the full length of the fairing. Two functionally redundant release nuts and studs provide structural continuity at the base of the fairing at each trisector separation rail interface. The fairing trisectors are jettisoned by actuating the release nut and studs first and then by detonating the linear explosive assembly in the thrusting joint cylinder rail cavity. The bellows

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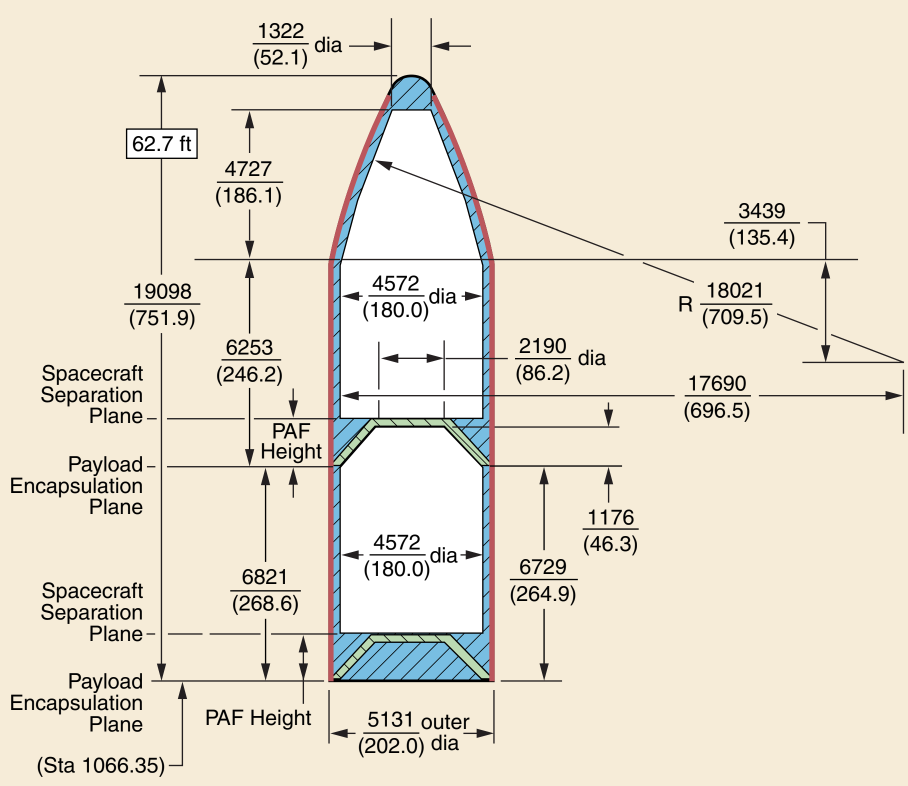


| Payload Attach Fittings | |
|---|---|
| PAF | Height mm/(in.) |
| 937-5 | 2283/(89.9) |
| 1194-5 | 2088/(82.2) |
| 1575-5 | 1801/(70.9) |
| 1664-5 | 2121/(83.5) |
| 1666-5 | 2134/(84.0) |

**Figure 3-9. Delta IV Heavy 5-m-dia by 19.1-m-Long Dual-Manifest Fairing Payload Envelope**

assembly in each cylinder rail retains the combustion product gases, preventing contamination of the payload during the fairing separation event.

The baseline acoustic blanket configuration is described in Table 3-1. Boeing can provide acoustic blankets varying in thickness from 38 mm (1.5 in.) up to 152 mm (6 in.) in 13-mm (0.5-in) increments, including the addition of acoustic blankets in the biconic nose above the 15-deg to 25-deg cone joint. Two payload access doors will be provided to suit the user's needs on a standard basis. The customer may choose from several door sizes that are all flight-qualified for production. Additional access doors can be provided. All access door sizes and locations must be coordinated with Delta Launch Services.

Figure 3-11 assumes that the payload stiffness guidelines in Section 4.2.3 are observed. Intrusion into any portion of the fairing envelope that is below the separation plane or local protuberances outside the envelope requires coordination with and approval by Delta Launch Services.

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- Fairing Envelope
- Usable Payload Static Envelope
- Payload Fitting
- Acoustic Blankets

Notes:

All dimensions are in mm/(in.)

Acoustic blanket thickness is 114.3 mm (4.5 in.) in nose and cylindrical section.

Boeing requires definition of payload within 51 mm (2.0 in.) payload envelope.

Projections of spacecraft appendages below the spacecraft separation plane may be permitted but must be coordinated with Delta Launch Services.

| Payload Attach Fittings | |
|---|---|
| PAF | Height mm/(in.) |
| 937-5 | 2283/(89.9) |
| 1194-5 | 2088/(82.2) |
| 1575-5 | 1801/(70.9) |
| 1664-5 | 2121/(83.5) |
| 1666-5 | 2134/(84.0) |

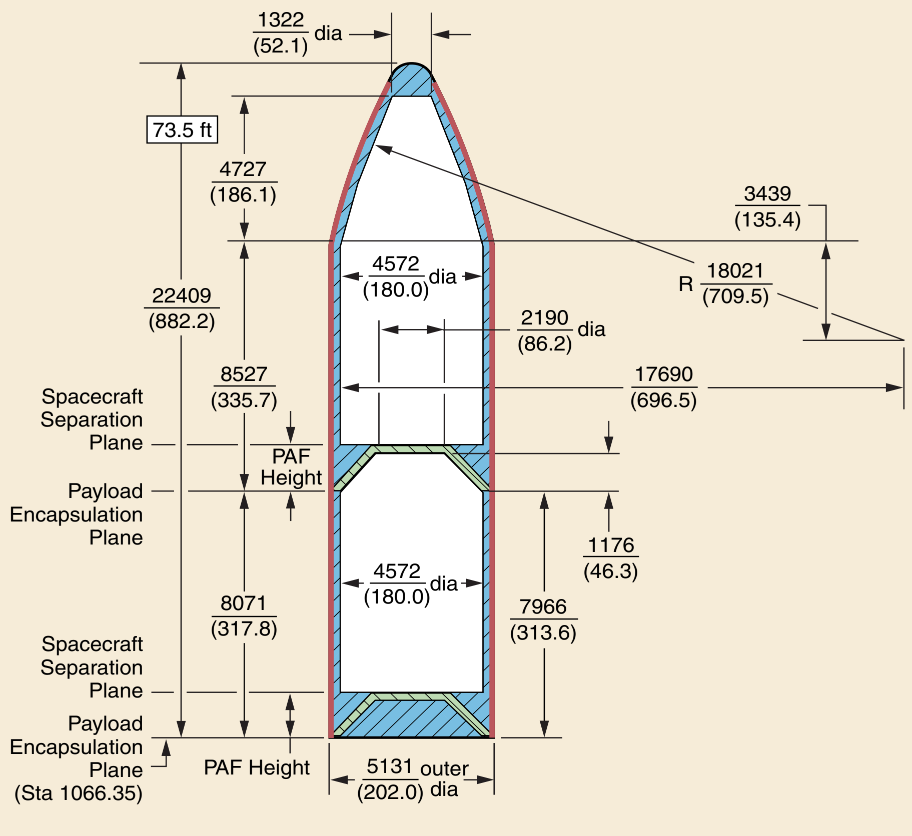


**Figure 3-10. Delta IV Heavy 5-m-dia by 22.4-m-Long Dual-Manifest Fairing Payload Envelope**

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- Fairing Envelope
- Usable Payload Dynamic Envelope
- Payload Attach Fitting
- Acoustic Blankets

Notes:

All dimensions are in mm/(in.)

Acoustic blanket thickness is 76.2 mm (3 in.) in nose, cylindrical section, and base.

Boeing requires definition of payload features within 51 mm (2.0 in.) of payload envelope.

Projections of payload appendages below the payload separation plane may be permitted but must be coordinated with Delta Launch Services.

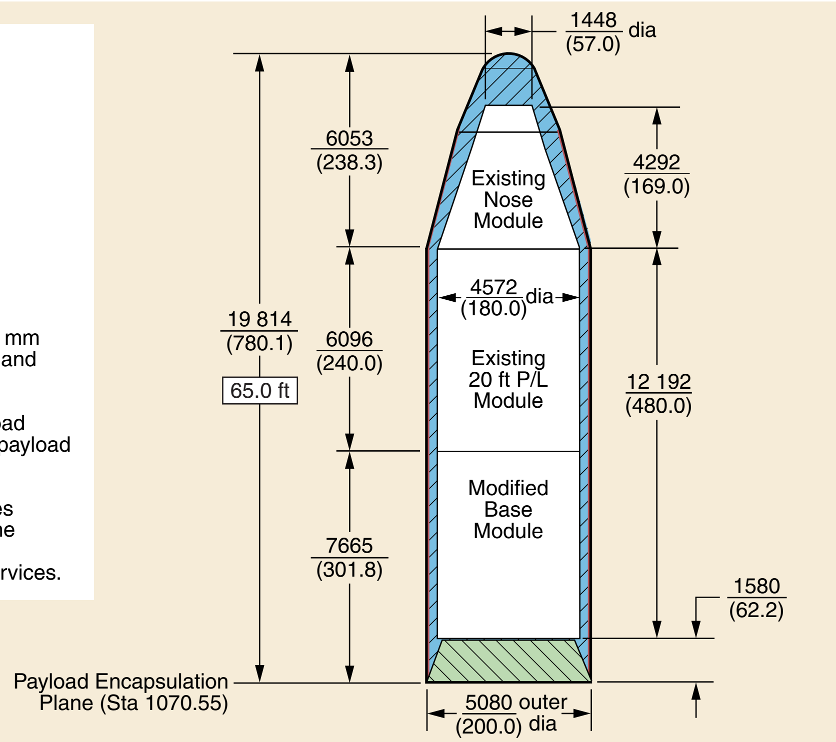


**Figure 3-11. Delta IV Heavy 5-m-dia by 19.8-m-Long Metallic Fairing Payload Envelope—4394-5 PAF**

# Section 4
# PAYLOAD ENVIRONMENTS

This section describes the environments to which the payload is exposed from delivery at launch site through launch. Section 4.1 presents prelaunch environments for processing facilities at both the Eastern and Western ranges. Section 4.2 presents the Delta IV launch and flight environments for the payload.

## 4.1 PRELAUNCH ENVIRONMENTS

### 4.1.1 Air-Conditioning and Gaseous Nitrogen ($GN_2$) Purge

During processing, the payload environment is carefully controlled for temperature, relative humidity, and cleanliness. This includes the processing conducted before the payload is encapsulated within the payload fairing, transported to the launch pad, and lifted onto the Delta IV launch vehicle. During transportation, air-conditioning is supplied through a portable environmental control system (ECS). Air-conditioning is supplied to the payload by an umbilical after the encapsulated payload is mated to the Delta IV launch vehicle. The payload air-distribution system (Figure 4-1 for 4-m and 5-m composite fairings and Figure 4-2 for the 5-m metallic fairing option) provides air at the required cleanliness, temperature, relative humidity, and flow rate. The air is supplied to the payload at a maximum flow rate of 36.3 kg/min to 72.6 kg/min (80 to 160 lb/min) for 4-m fairing launch vehicles; and 90.7 kg/min to 136.0 kg/min (200 to

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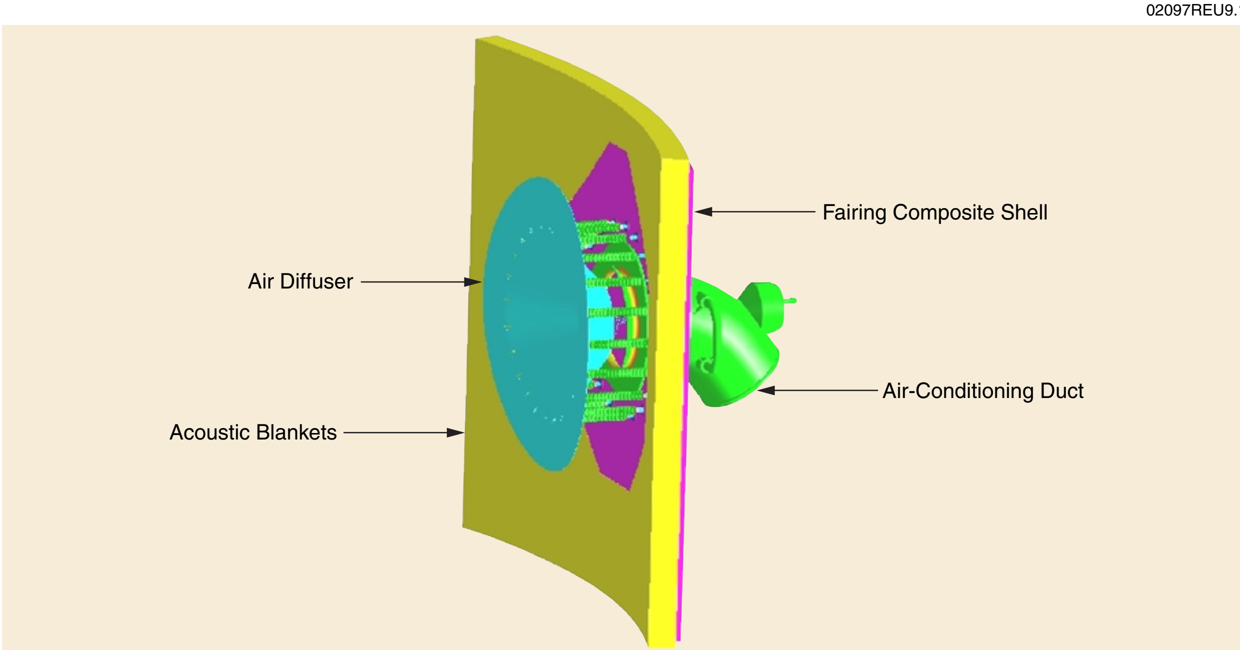


Figure 4-1. Standard 4-m Composite Fairing and 5-m Composite Fairing Air-Conditioning Duct Inlet Configuration

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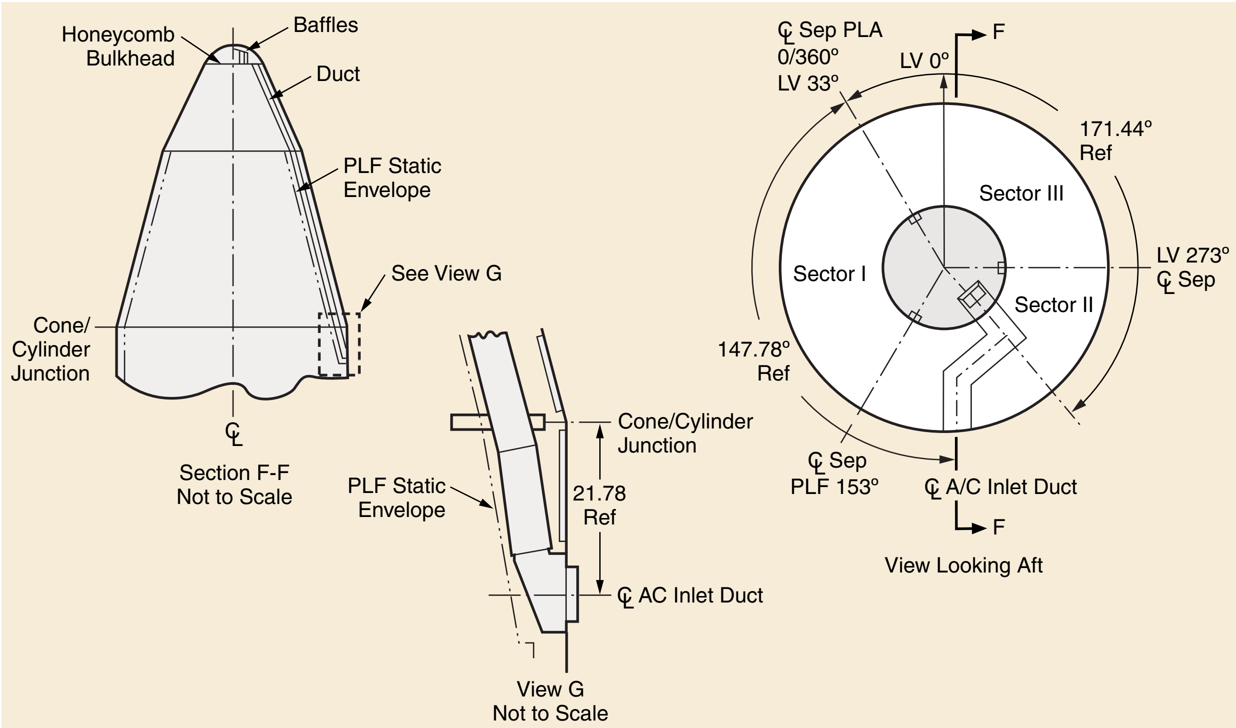


**Figure 4-2. 5-m Metallic Fairing Payload Air-Distribution System**

300 lb/min) for 5-m fairing launch vehicles. Air flow around the payload is discharged through vents in the aft end of the fairing. Both Space Launch Complexes, SLC-37 and SLC-6, have a backup system for fairing air-conditioning. The 4-m and 5-m composite fairings' air-distribution systems use a diffuser on the inlet air-conditioning duct at the fairing interface. The metallic fairing air-distribution system is ducted up to the nose and the air enters the payload compartment through a diffuser. The air-conditioning umbilical is pulled away at liftoff by lanyard disconnects, and the inlet door on the fairing automatically closes.

A $GN_2$ purge line to the payload can be accommodated through the air-conditioning duct. The air-conditioning duct is below the cone/cylinder junction in the Quad I/Quad II half for the 4-m and 5-m composite fairings and in the middle of trisector II for the 5-m metallic fairing. Unique mission requirements or equipment and mission-specific options should be coordinated with Delta Launch Services.

Various payload processing facilities are available at the launch site for use by the customer. Environmental control specifications for these facilities are listed in Tables 4-1 and 4-2 for the Eastern and Western ranges, respectively. The facilities to be used depend on payload program requirements.

### 4.1.2 MST Enclosure

The mobile service tower (MST) provides customers access to the encapsulated payload once it is mated to the launch vehicle. This enclosure is located at levels 8 to 12 in the MST to provide

**Table 4-1. Eastern Range Facility Environments**

| Location | | Temperature | Relative humidity[1] | Particulate class[2] |
|---|---|---|---|---|
| Encapsulated payload | Mobile | 18.3° to 29.4° ±2.8°C (65° to 85°±5°F) | Max 50%<br>Min not controlled | Class 5000[3] |
| MST[4] | Environmental enclosure | 20° to 25.6°C (68° to 78°F) | Max 75%<br>Min not controlled | Not controlled |
| | Fairing | Any specified between 10° and 29.4° ±2.8°C (50° and 85° ±5°F) | 20 to 50% | Class 5000 inlet |
| Astrotech | Building 9: airlock, high bays, storage bays | 21.0° ± 2.8°C (70° ± 5°F) | 40 ± 60% | Class 100,000[3]<br>Functional 10,000 |

Note: The facilities listed can only limit the maximum humidity level. The facilities do not have the capability to maintain a minimum RH value.
These numbers are provided for planning purposes only. Specific values should be obtained from the controlling agency.
[1]PCES only: A 50% relative humidity maximum can be maintained at a temperature of 18.3°C (65°F). At higher temperatures, the relative humidity can be reduced by drying the conditioned air to a minimum specific humidity of 48 grains of moisture per 0.45 kg (1 lb) of dry air.
[2]Verified/sampled at duct outlet.
[3]FED-STD-209D.
[4]A backup system exists for the mobile service tower (MST) air-conditioning.

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**Table 4-2. Western Range Facility Environments**

| Location | | Temperature | Relative humidity | Particulate Class |
|---|---|---|---|---|
| Encapsulated payload | Mobile | 18.3° to 29.4° ±2.8°C (65° to 85° ±5°F) | Max 50%<br>Min uncontrolled | Class 5000[1] |
| Spaceport Systems International | Payload Checkout Cells | 21.1° ±2.8°C (70° ±5°) | 30 to 50% | Class 100,000[1] HEPA filtered, Class 5000 at inlet |
| Astrotech | Payload Processing Rooms | 15.5° to 26.6° ±1.2°C[2] (60° to 80° ±2°F) | 35 to 60% ±10[2] | Class 100,000[2] functional 10,000 |
| MST | SLC-6 MST/MAS | Not controlled | Not controlled | Not controlled |
| | Fairing | Any specified between 10° and 29.4° ±2.8°C (50° and 85° ±5°F) | 20 to 50% | Class 5000 inlet[2] |

[1]FED-STD-209D.
[2]Controlled per customer requirement within range, shown.

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weather protection. A portable clean environmental shelter (PCES), as shown in Figure 4-3, can be provided that allows environmentally controlled (class 5000) access through one payload fairing (PLF) door within the MST operational constraints while the encapsulated payload is housed within the MST. Multiple doors may be accessed with PCESs. This will be considered on a case-by-case basis. The PCES comprises three major components: (1) entrance/changing chamber, (2) working chamber, and (3) PLF interface. This interface provides shielding/sealing around the PLF access doors and protects the encapsulated payload from being contaminated.

### 4.1.3 Radiation and Electromagnetic Environments

The Delta IV launch vehicle transmits on several frequencies to provide launch vehicle telemetry and beacon signals to the appropriate ground stations and the tracking and data relay satellite system (TDRSS). The launch vehicle also has uplink capability for command destruct. An S-band

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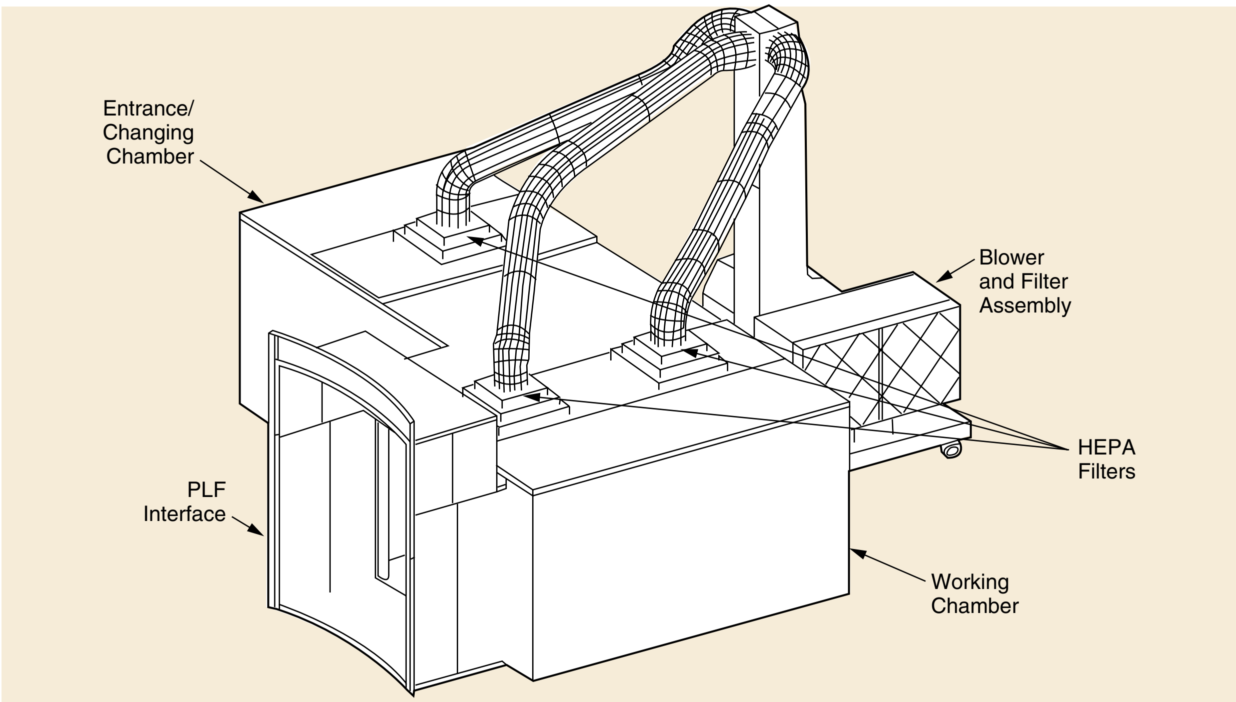


**Figure 4-3. Portable Clean Environmental Shelter (PCES)**

telemetry system, two command receiver decoder (CRD) systems, and a C-band transponder (beacon) are provided on the second stage. The radiation characteristics of these systems are listed in Table 4-3. The radio frequency (RF) systems are switched on prior to launch and remain on until mission completion.

At the Eastern and Western ranges, the electromagnetic environment to which the satellite is exposed results from the operation of range radars and launch vehicle transmitters and antennas. The maximum RF environment at the launch site is controlled through coordination with the

**Table 4-3. Delta IV Transmitter Characteristics**

| | **Second-stage telemetry radiation characteristics** | **Second-stage C-band beacon characteristics** |
|---|---|---|
| | **Transmitter** | |
| Nominal frequency | 2241.5 MHz | 5765 MHz (transmit)<br>5690 MHz (receive) |
| Power output | 30.0 W min | 400 W min peak,<br>0.52 W min average |
| Modulation data rate | 1.92 Mbps (Delta IV Heavy) or 1.28 Mbps (Delta IV Medium) from launch to conclusion of range safety authority and 192 kbps via TDRSS until the contamination and collision avoidance maneuver (CCAM) | 6 MHz at 6 dB |
| | **Antenna** | |
| | **S-Band** | **C-Band** |
| Type | Patch | Spiral |
| Polarization | Right-hand circular | Right-hand circular |
| Location | 5-m second stage – Sta 1172.88<br>4-m second stage – Sta 1232.36 | 5-m Sta 1172.88<br>4-m Sta 1232.36 |
| Pattern coverage | Launch to 2 deg above radar horizon = 95%<br>From 2 deg above radar horizon to CCAM = 95% ±60 deg boresight via one of four selected antennas around the circumference of the launch vehicle | |

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range and with protective masking of radars. The launch pads are protected to an environment of 20 V/m at frequencies from 14 kHz to 40 GHz and 40 V/m in the S- and C-band frequencies used for vehicle range tracking and telemetry.

The RF environment is analyzed to ensure that the satellite transmitters are compatible with the launch vehicle avionics and ordnance systems. RF compatibility is also analyzed to verify that the launch vehicle and satellite transmitter frequencies do not have interfering intermodulation products or image-rejection problems. For dual-manifested missions, RF co-passenger compatibility is also required.

Customer should contact Delta Launch Services for induced RF environments.

### 4.1.4 Electrostatic Potential

During ground processing, the payload must be equipped with an accessible ground attachment point to which a conventional alligator-clip ground strap can be attached. Preferably, the ground attachment point is located on or near the base of the payload, at least 31.8 mm (1.25 in.) above the separation plane. The launch vehicle/payload interface provides the conductive path for grounding the payload to the launch vehicle. Therefore, dielectric coating should not be applied to the payload interface. The electrical resistance of the payload-to-payload attach fitting (PAF) interface surfaces must be 0.0025 ohm or less and is verified during payload-to-PAF mate (reference MIL-STD-464, Class R).

### 4.1.5 Contamination and Cleanliness

The following guidelines and practices ensure that payload contamination is minimized during encapsulation, transport, and launch site operations.

Precautions are taken during manufacture, assembly, test, and shipment of the Delta IV second-stage area, fairing, and PAF to prevent contaminant accumulations.

The fairing and PAF are cleaned at the manufacturing site using approved solvents, then inspected for cleanliness prior to double-bagging for shipment to the launch site. Table 4-4 provides Boeing STP0407 visible cleanliness (VC) levels with their NASA SN-C-0005 equivalents. STP0407 defines the cleanliness levels available to payload customers. The standard level for a Delta IV mission using a composite fairing is VC 3. Other cleanliness levels must be negotiated with Delta Launch Services.

Encapsulation of the payload into the fairing is performed in a facility that is environmentally controlled to class 100,000 conditions. All handling equipment is cleanroom compatible and is cleaned and inspected before it enters the facility. These environmentally controlled conditions are available for all remote encapsulation facilities. A transporter provided by Boeing is used to transport the encapsulated payload to the launch pad and a portable environmental control system is used to provide environmental protection for the payload during transport. Personnel and

**Table 4-4. Cleanliness Level Definitions**

| Boeing STP0407-0X | NASA SN-C-0005 |
|---|---|
| VC 1 | None |
| VC 2 | VC Standard |
| VC 3 | VC Highly Sensitive, Standard Level |
| VC 4 | VC Sensitive + UV (Closest equivalent; Boeing is more critical) |
| VC 5 | VC Highly Sensitive |
| VC 6 | VC Highly Sensitive + UV |
| VC 7 | VC Highly Sensitive + NVR Level A |

**VC 1—**All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are defined as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. Inspection operations shall be performed under normal shop lighting conditions at a maximum distance of 0.915 m (3 ft).

**VC 2—**All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are defined as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. Inspection operations shall be performed at incident light levels of 538.2 lux (50 foot-candles [fc]) and observation distances of 1.52 m to 3.05 m (5 ft to 10 ft).

**VC 3—**All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are identified as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. Incident light levels shall be 1076.4 lux to 2152.8 lux (100 fc to 200 fc) at an observation distance of 45.2 cm (18 in.) or less.

**VC 4—**All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are identified as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. This level requires no particulate count. The source of incident light shall be a 300-W explosion-proof droplight held at distance of 1.52 m (5 ft), maximum, from the local area of inspection. There shall be no hydrocarbon contamination on surfaces specifying VC 4 cleanliness.

**VC 5—**All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are identified as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. This level requires no particulate count. Incident light levels shall be 1076.4 lux to 2152.8 lux (100 fc to 200 fc) at an observation distance of 15.2 cm to 45.7 cm (6 in. to 18 in.). Cleaning must be done in a class 100,000 or better clean-room.

**VC 6—**All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are identified as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. This level requires no particulate count. Incident light levels shall be 1076.4 lux to 2152.8 lux (100 fc to 200 fc) at an observation distance of 15.2 cm to 45.7 cm (6 in. to 18 in.). Additional incident light requirements are 8 W minimum of long-wave ultraviolet (UV) light at 15.2 cm to 45.7-cm (6 in. to 18-in.) observation distance in a darkened work area. Protective eye-wear may be used as required with UV lamps. Cleaning must be done in a class 100,000 or better cleanroom.

**VC 7—**All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are identified as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. This level requires no particulate count. Incident light levels shall be 1076.4 lux to 2152.8 lux (100 fc to 200 fc) at an observation distance of 15.2 cm to 45.7 cm (6 in. to 18 in.). Cleaning must be done in a class 100,000 or better clean-room. The nonvolatile residue (NVR) is to be one microgram or less per square centimeter (one milligram or less per square foot) of surface area as determined by the laboratory using a minimum of two random NVR samples per quadrant per bisector or trisector.

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operational controls are employed during payload encapsulation and access at the pad (if required) to maintain payload cleanliness. Such standard controls are detailed in the Delta IV Contamination Control Implementation Plan, MDC 98H1056. A portable environmental control system will provide temperature and air-flow control during transport to the launch site.

## 4.2 LAUNCH AND FLIGHT ENVIRONMENTS

The following payload launch environments, such as low- and high-frequency vibration, acceleration transients, shock, velocity increments, and payload status, are our best predictions as to the launch environments during flight. The actual data will be obtained from the launch vehicle telemetry system for validation.

### 4.2.1 Fairing Internal Pressure Environment

As a Delta IV launch vehicle ascends through the atmosphere, venting occurs through the aft section of the fairing and other leak paths in the vehicle. The expected extremes of payload fairing internal pressure during ascent are presented in Figures 4-4, 4-5, 4-6, 4-7, 4-8, and 4-9 for the Delta IV family of launch vehicles.

The rate of pressure decay inside the fairing is also important in establishing the payload flight environment. The fairing internal pressure decay rate for all Delta IV launch vehicles will generally be constrained to a sustained level of 2.76 kPa/sec (0.4 psi/sec) or less with a single brief allowable peak of up to 4.14 kPa/sec (0.6 psi/sec).

### 4.2.2 Thermal Environment

Prior to and during launch, the payload fairing and second stage contribute to the thermal environment of the payload.

**4.2.2.1 Payload Fairing Thermal Environment.** The ascent thermal environments of the Delta IV fairing surfaces facing the payload are shown in Figure 4-10 for the 4-m composite fairings, Figure 4-11 for the 5-m composite fairings, and Figure 4-12 for the 5-m metallic fairing. Temperatures are provided for the PLF inner acoustic blankets, unblanketed nose cap, and separation rail sections facing the payload. All temperatures presented are maximum upper bounds based on depressed (worst-case) versions of the trajectory and hot-day launch conditions. Cooler days would have cooler starting temperatures.

The acoustic blankets provide a relatively cool radiation environment by effectively shielding the payload from ascent heating in blanketed areas. This is particularly the case for the 4-m and 5-m composite fairings, which satisfy the Commercial Space Transportation Advisory Committee (COMSTAC) limit for maximum heat flux from the fairing to the payload of 500 W/m$^2$ by a large margin as a result of low blanket temperatures. Delta IV 5-m metallic fairings, which cover up to the forward end of the 15-deg nose cone, also satisfy this limit. Figures 4-10, 4-11, and 4-12 depict the areas of the various Delta IV fairings that are typically blanketed. There may be slight variations in blanket coverage areas based on mission requirements.

Unless otherwise requested, fairing jettison for standard Delta IV missions will occur shortly after the 3-sigma high theoretical free molecular heating for a flat plate normal to the free stream drops below 1135 W/m$^2$ (360 Btu/hr ft$^2$) based on the 1962 US Standard Atmosphere. Additional theoretical free molecular heating rates at fairing jettison (e.g., 1009 W/m$^2$ [(320 Btu/hr ft$^2$]) can be accommodated by the Delta IV family through coordination with Delta Launch Services.

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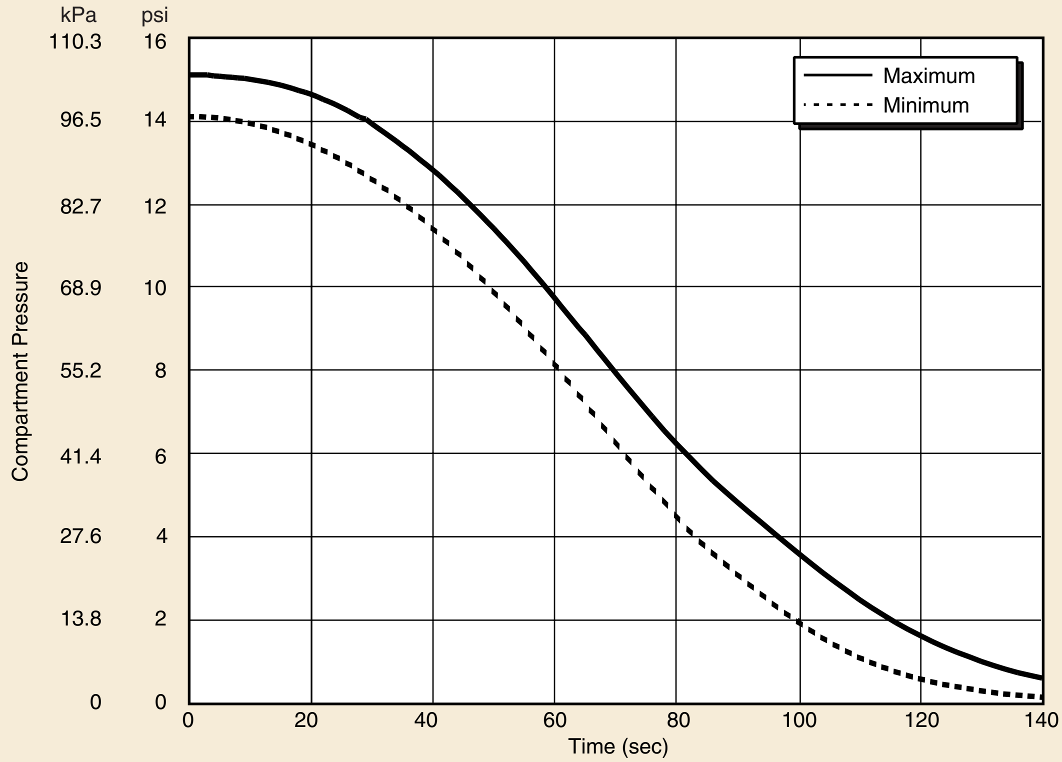


**Figure 4-4. Delta IV Medium Absolute Pressure Envelope**

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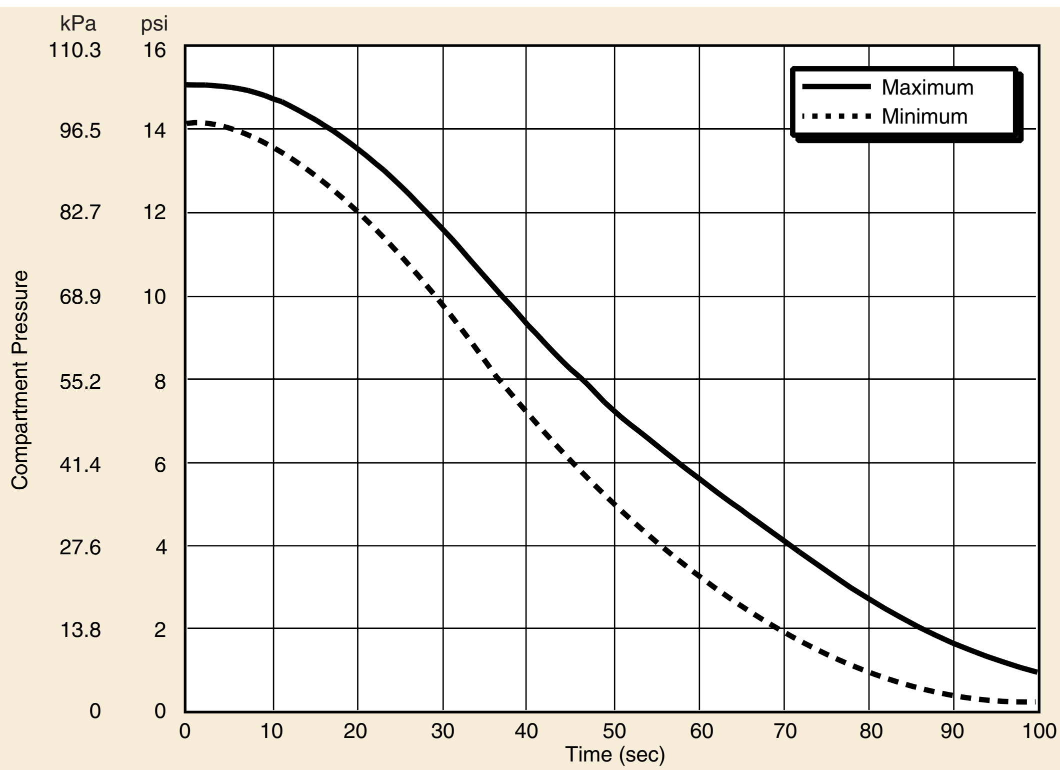


**Figure 4-5. Delta IV Medium-Plus (4,2) Absolute Pressure Envelope**

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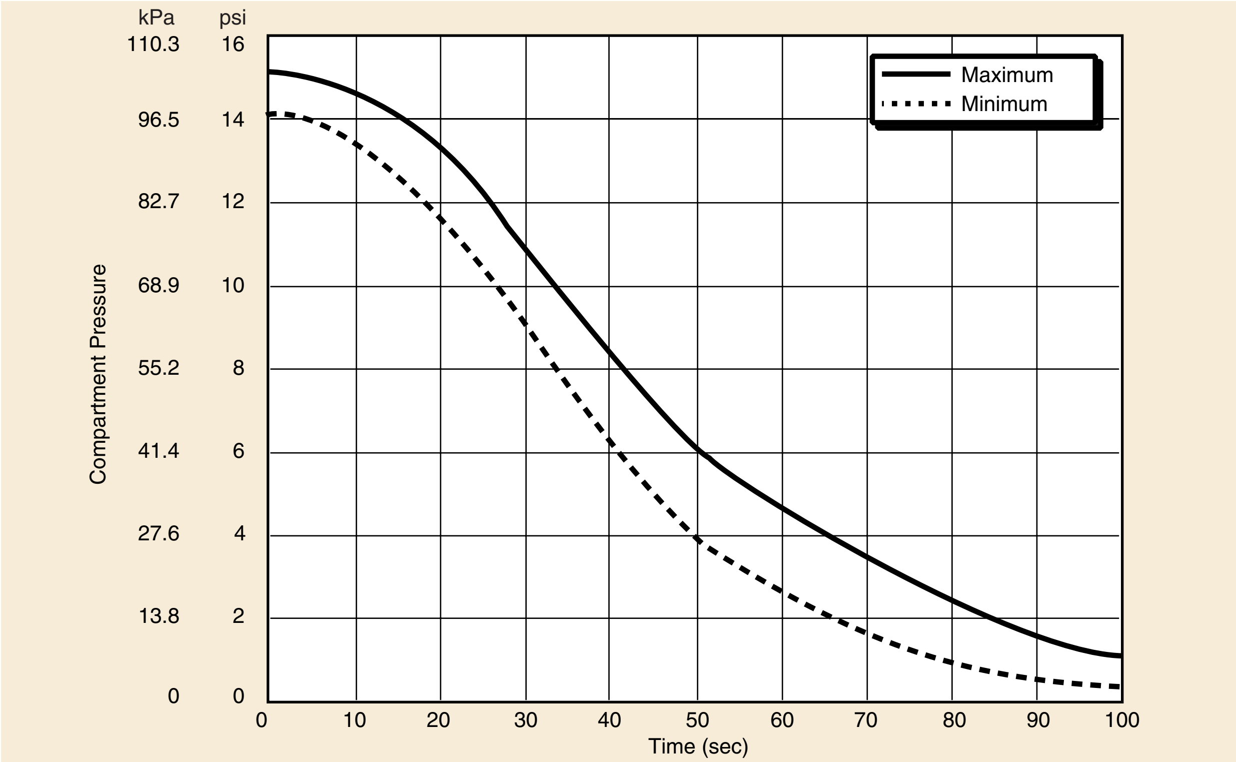


**Figure 4-6. Delta IV Medium-Plus (5,2) Absolute Pressure Envelope**

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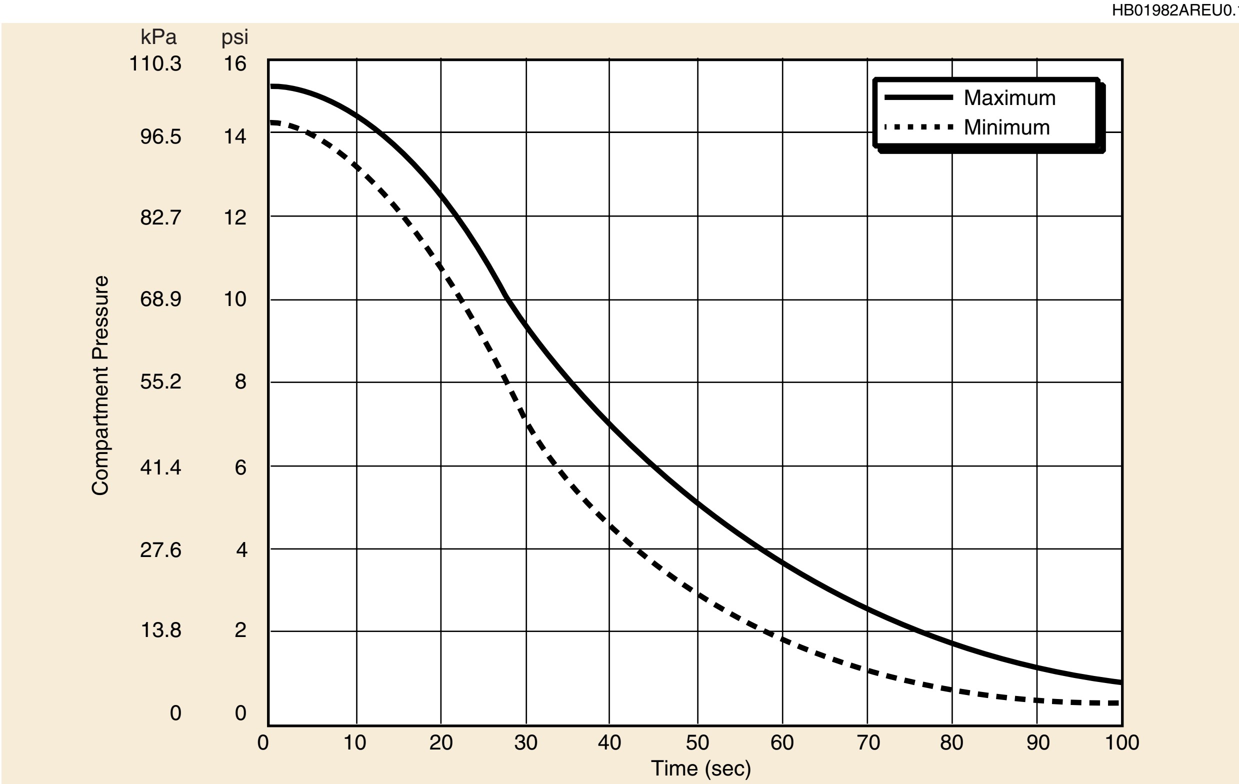


**Figure 4-7. Delta IV Medium-Plus (5,4) Absolute Pressure Envelope**

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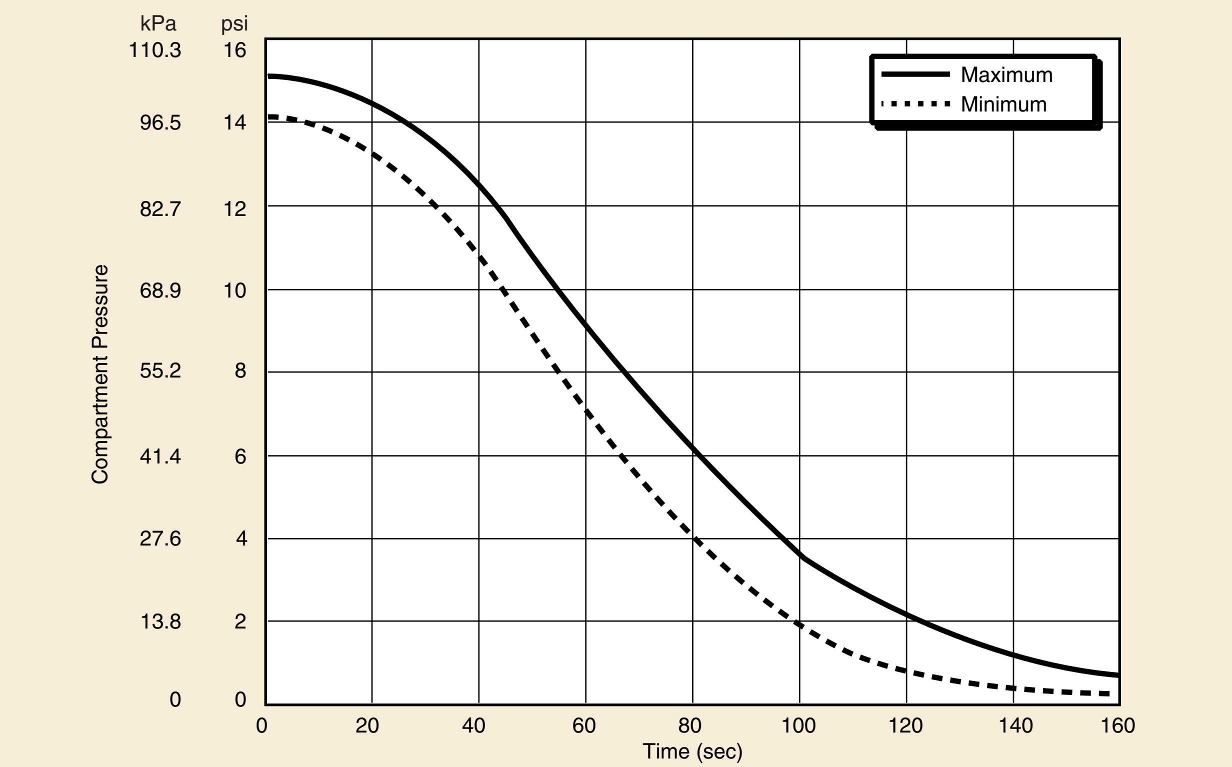


**Figure 4-8. Delta IV Heavy (Composite PLF) Absolute Pressure Envelope**

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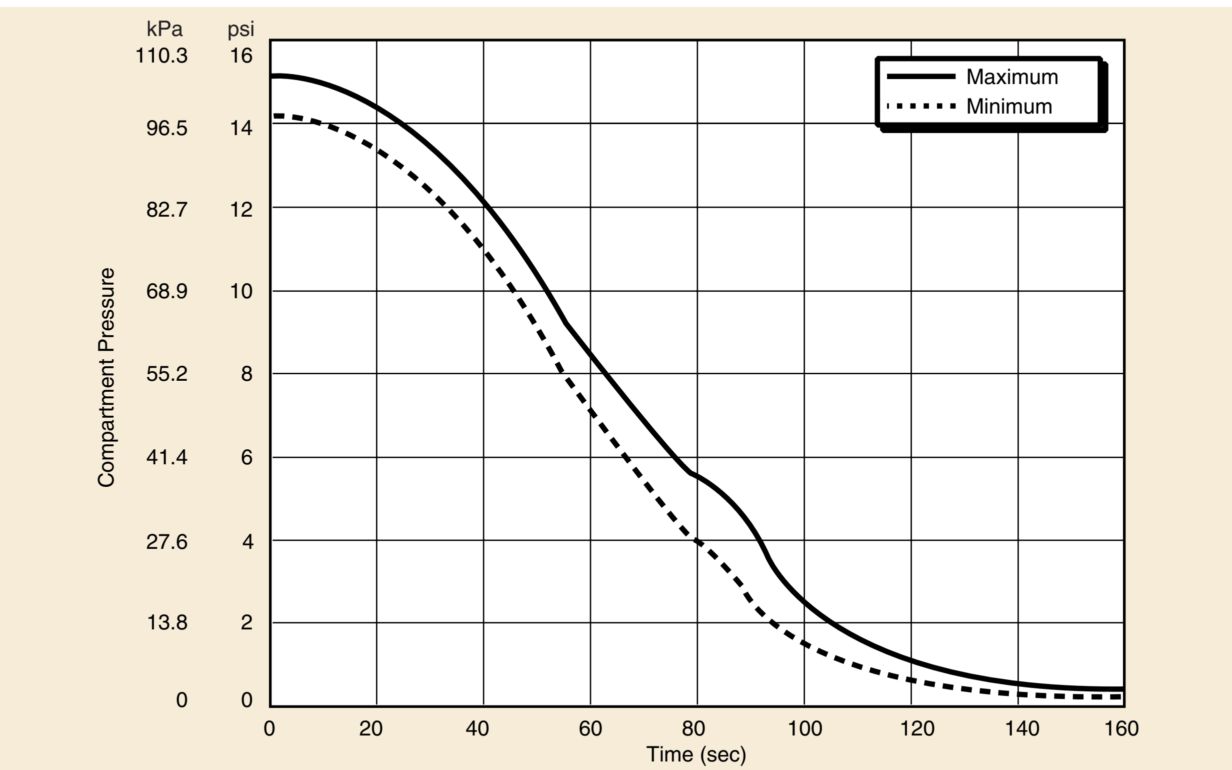


**Figure 4-9. Delta IV Heavy (Metallic PLF) Absolute Pressure Envelope**

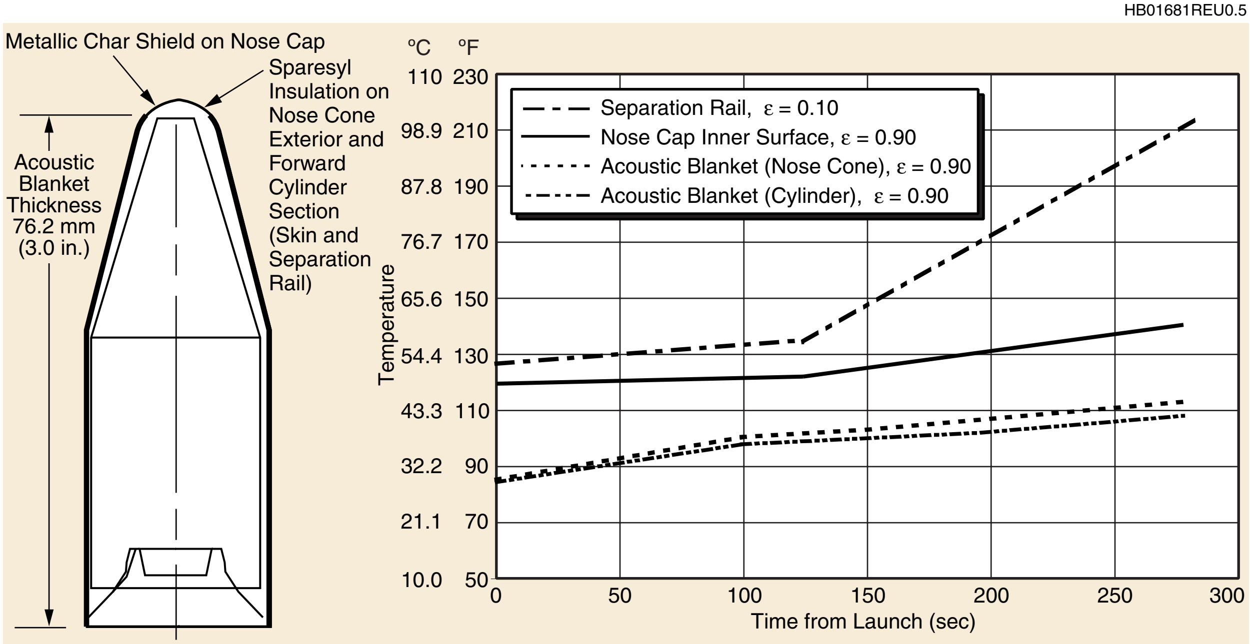


**Figure 4-10. Inner Surface Temperature (Environments to Spacecraft), 4-m Composite PLFs**

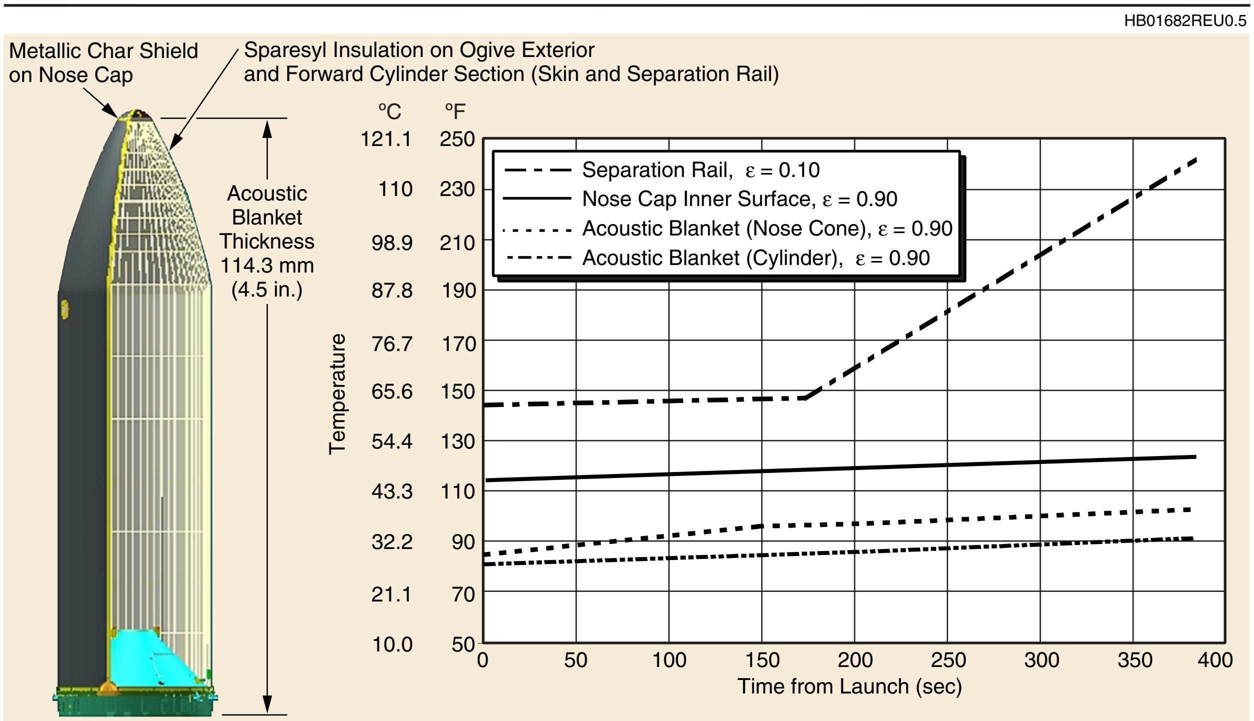


**Figure 4-11. Inner Surface Temperature (Environments to Spacecraft), 5-m Composite PLFs**

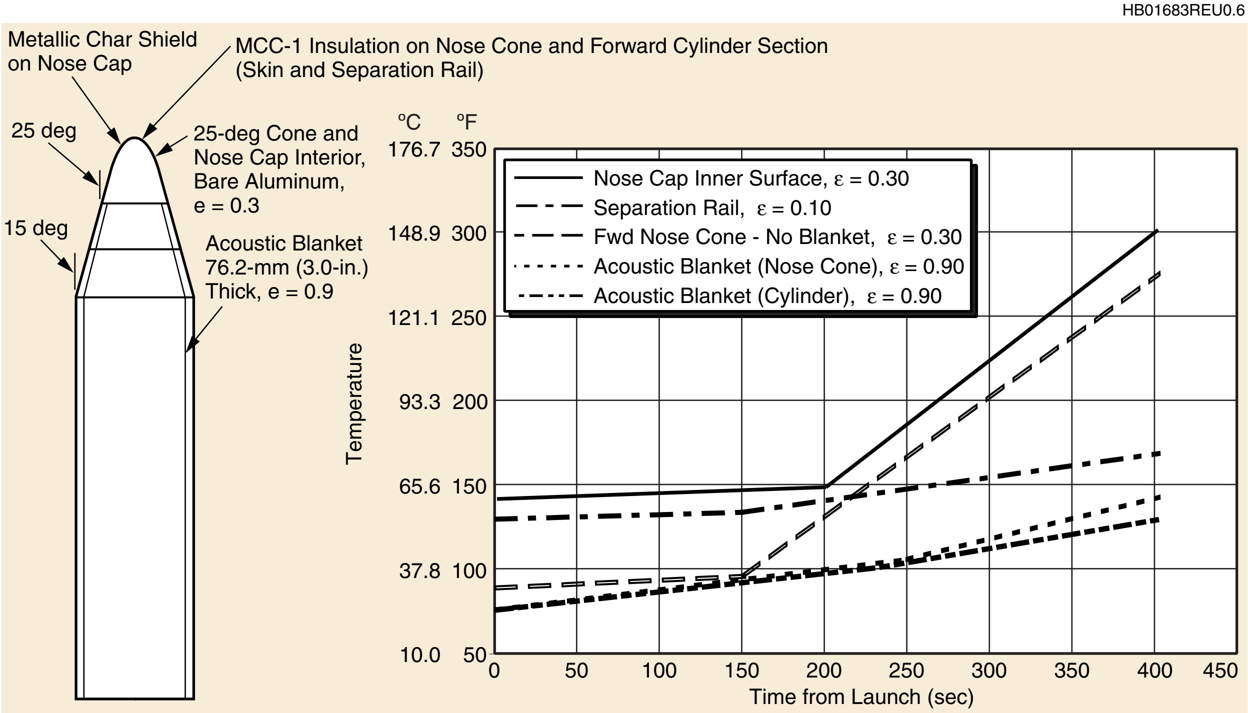


**Figure 4-12. Inner Surface Temperature (Environments to Spacecraft), 5-m Aluminum Isogrid PLFs**

**4.2.2.2 On-Orbit Thermal Environment.** During coast periods, the Delta IV launch vehicle can be oriented to meet specific sun-angle requirements. A slow roll during a long coast period can also be used to moderate orbital heating and cooling. The Delta IV roll rate for thermal control is typically 1.5 deg/sec for the 4-m second stage and 1.0 deg/sec for the 5-m second stage.

**4.2.2.3 Payload/Launch Vehicle Interface.** Boeing will perform a thermodynamic analysis using a customer-provided payload thermal model to define payload temperatures during ground and flight operations until payload jettison.

**4.2.2.4 Stage-Induced Thermal Environments.** The plume of the RL10B-2 engine does not impinge on the payload. Hydrazine thrusters, which are used for attitude control, are located on the equipment deck, aft of the main propellant tanks. Nozzles are pointed circumferentially and aft.

**4.2.2.5 In-Flight Contamination Environments.** Sources of contamination from the second-stage propulsion system and payload fairings have been quantified for Delta II and Delta III. Delta IV 4-m and 5-m composite PLFs are comparable to the Delta II and Delta III PLFs, with a unique acoustic blanket configuration that virtually eliminates launch vehicle's sources of contamination to the payload. The blankets are made of Melamine foam and are attached to the fairing with hook-and-loop fasteners. They are then covered with carbon-filled kapton face sheets, with all seams sealed with kapton tape. The PLFs and blankets are cleaned with isopropyl alcohol. During ascent, the blankets vent to the bottom of the PLF, away from the payload. Blanket pressures are kept below 827 Pad (0.12 psid) (with respect to the fairing internal pressure) to prevent debonding of the blankets. Blanket pressure models have been verified with flight data. Outgassing from non-metallics in the fairing is low due to the low composite fairing temperatures, which are generally below 48.9°C (120°F). Analysis shows that deposition on the payload envelope from exposed composite material and the carbon-filled sheets is less than 15Å.

Delta IV second-stage attitude control systems use hydrazine ($N_2H_4$) thrusters. The second-stage motor plumes do not expand enough to impinge on the payload envelope. For payload temperatures above 93 K (–293°F), only aniline from the $N_2H_4$ system plumes will deposit, but eventually evaporate, due to its high volatility. A collision contamination avoidance maneuver (CCAM) is performed after the payload has moved away from the second stage, with a goal of limiting payload contamination to less than 10 Å. Analysis shows that deposition levels are typically less than 1 Å.

### 4.2.3 Flight Dynamic Environment

The acoustic, sinusoidal, and shock environments cited herein are based on maximum flight levels for a 95th-percentile statistical estimate.

**4.2.3.1 Steady-State Acceleration.** Plots of representative steady-state axial accelerations during first-stage burn versus payload weight are shown in Figures 4-13, 4-14, 4-15, 4-16, and 4-17

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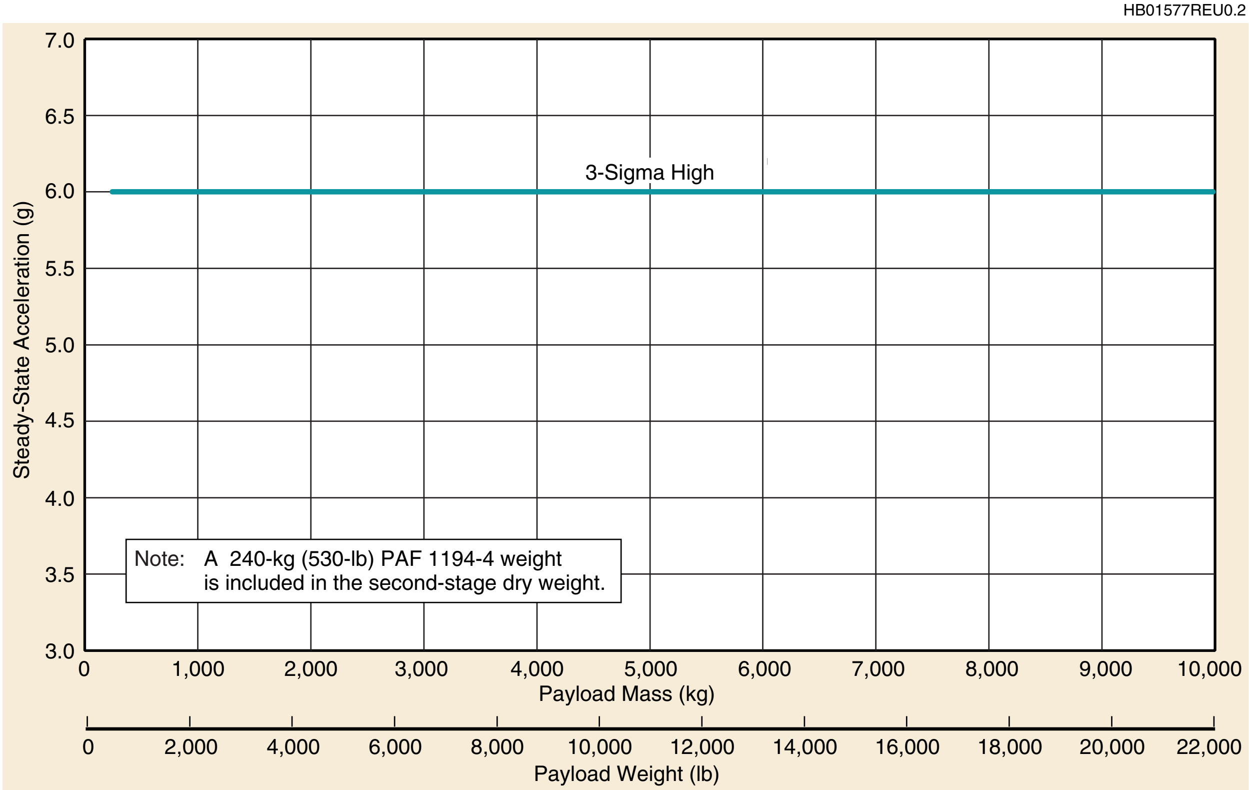


**Figure 4-13. Delta IV Medium Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second-Stage Payload Weight**

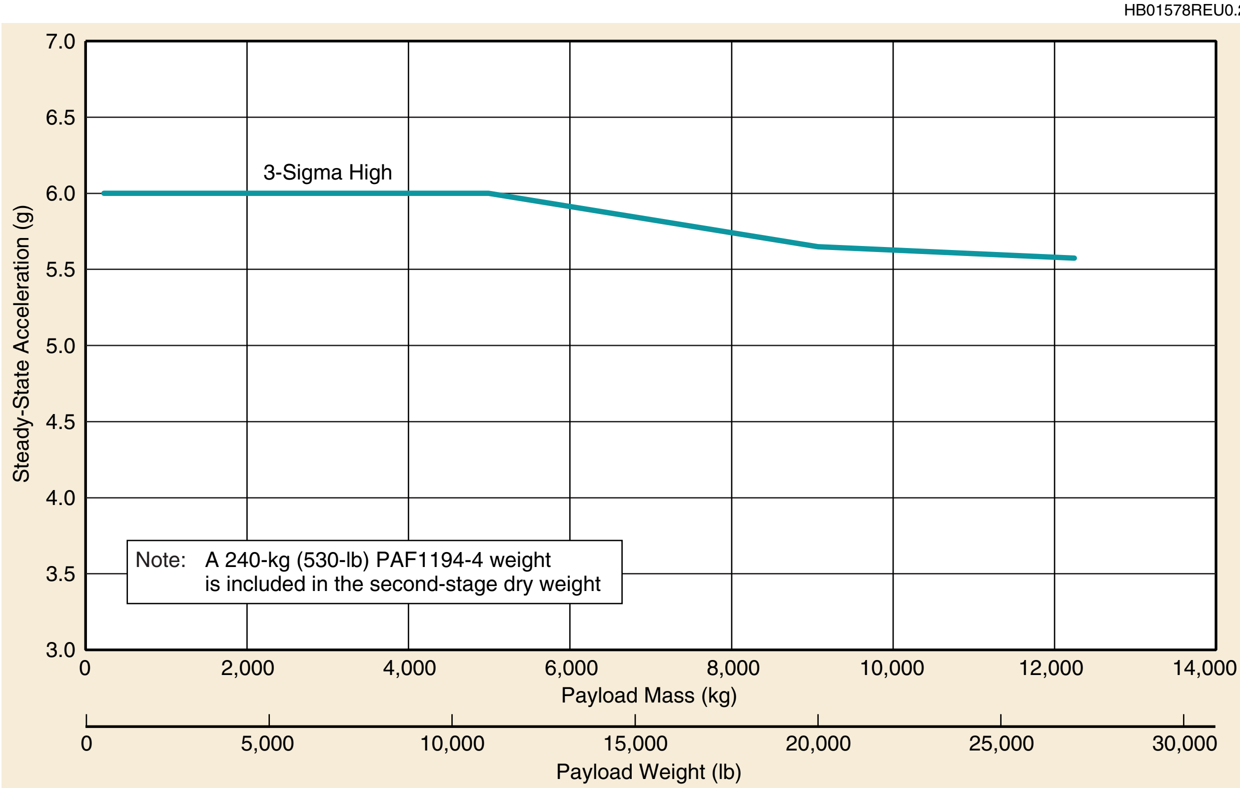


**Figure 4-14. Delta IV Medium-Plus (4,2) Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second-Stage Payload Weight**

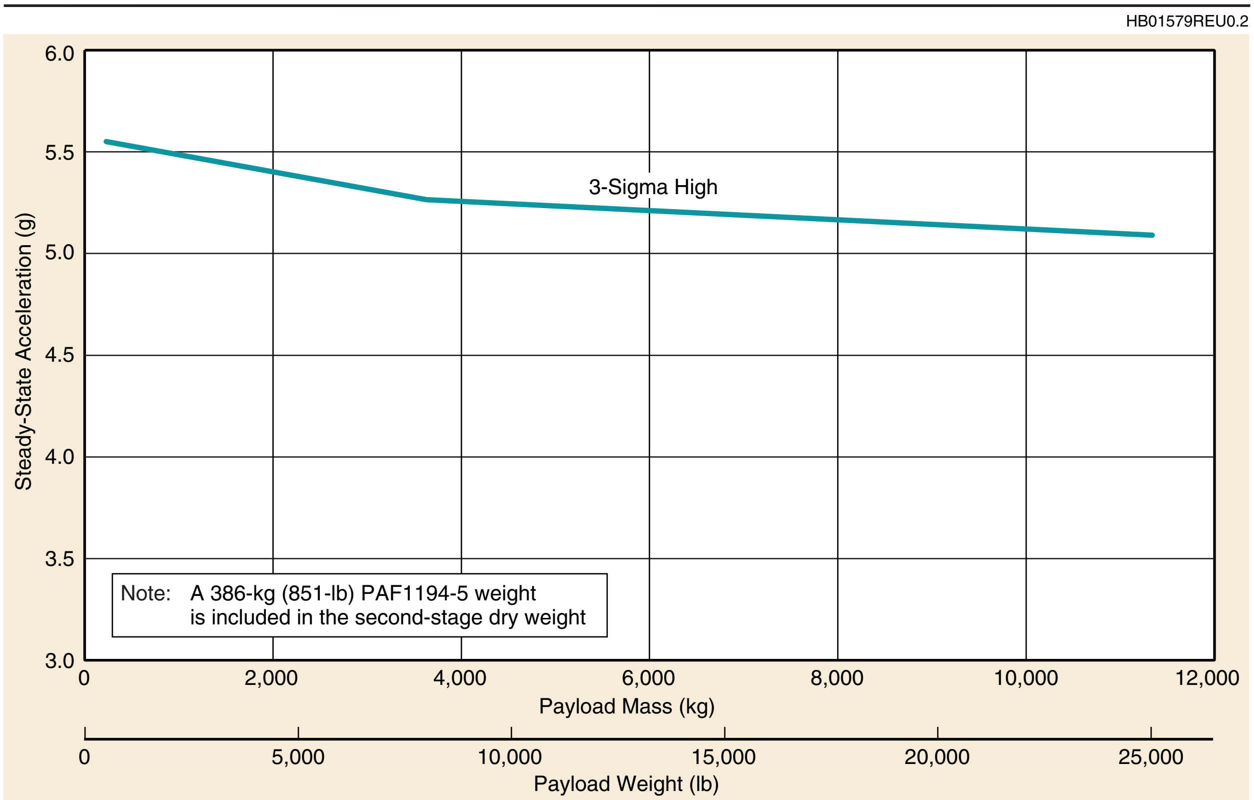


**Figure 4-15. Delta IV Medium-Plus (5,2) Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second-Stage Payload Weight**

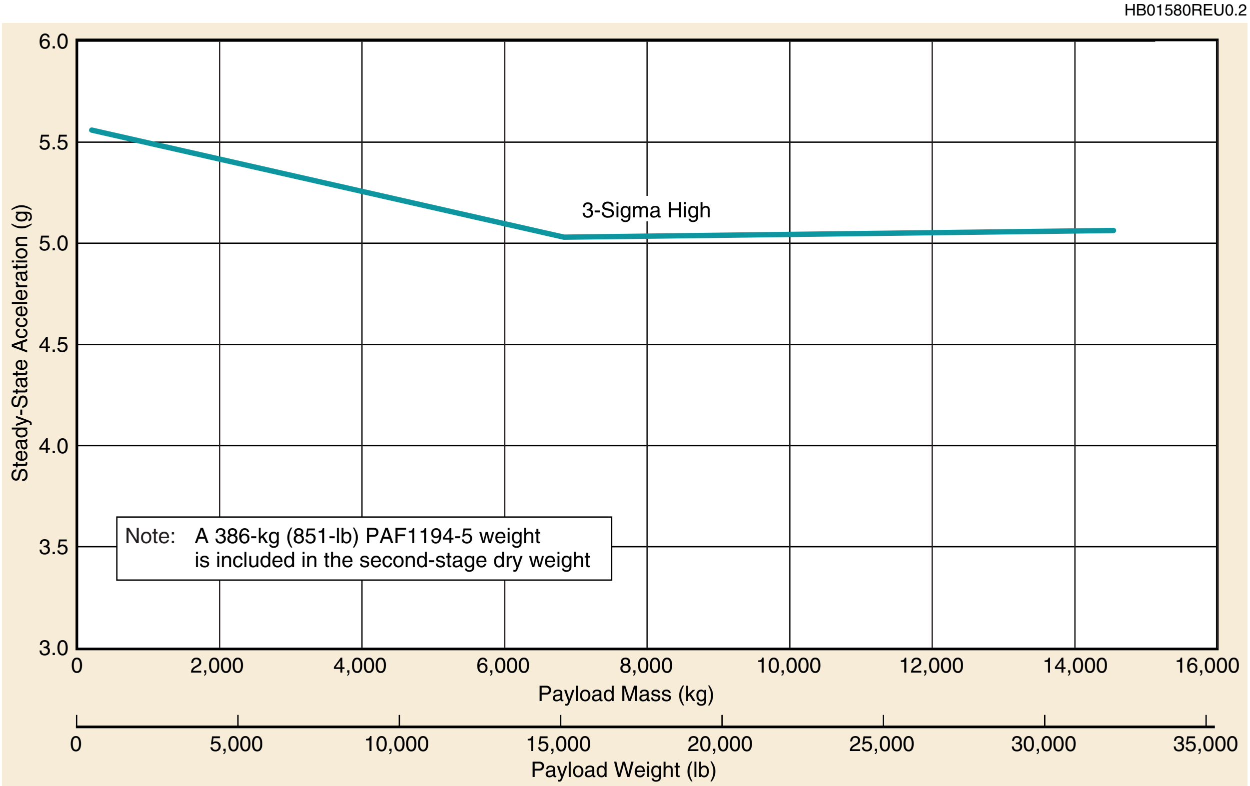


**Figure 4-16. Delta IV Medium-Plus (5,4) Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second-Stage Payload Weight**

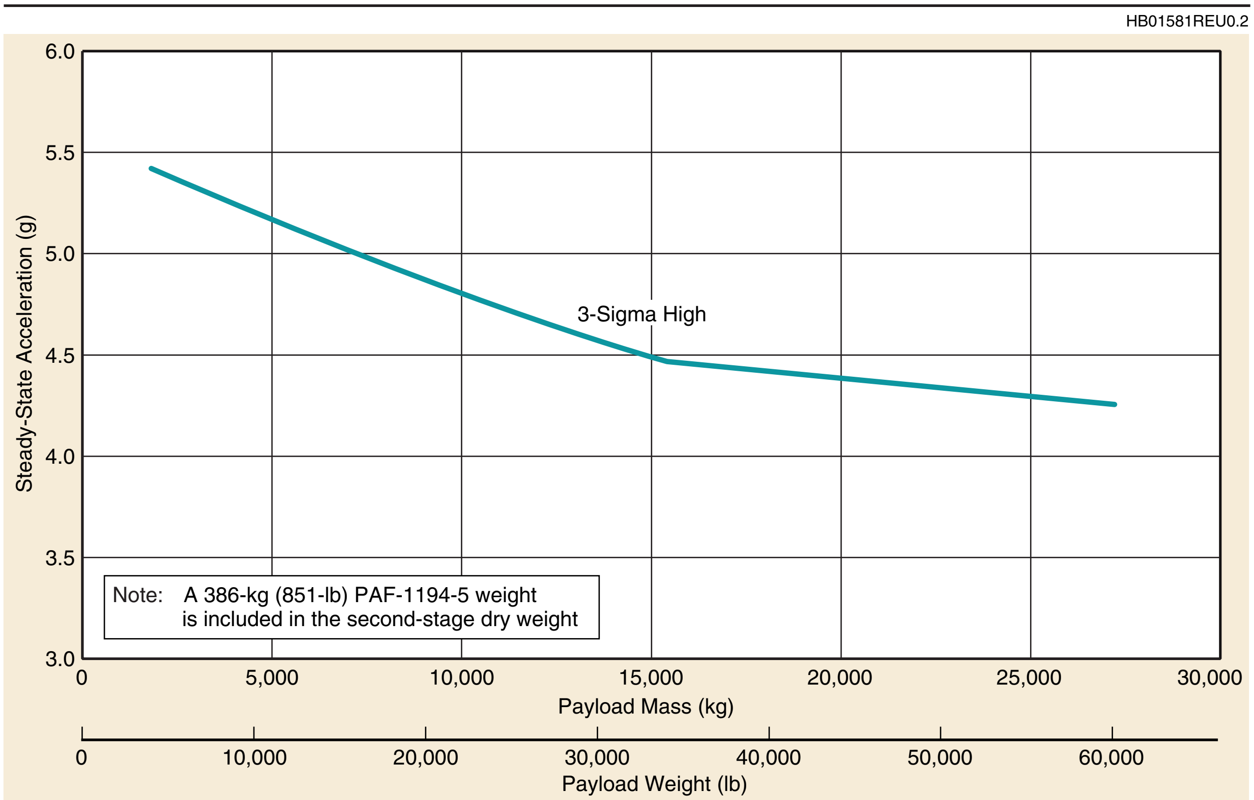


**Figure 4-17. Delta IV Heavy Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second-Stage Payload Weight**

for the Delta IV-M, -M+ (4,2), -M+ (5,2), -M+ (5,4), and -H vehicles, respectively. For a specific mission, the maximum axial acceleration may be reduced with common booster core (CBC) throttling, with some performance impacts. Please contact Delta Launch Services for details. Typical steady-state axial accelerations versus space vehicle weight at second-stage burnout are shown in Figures 4-18, 4-19, 4-20, 4-21, and 4-22 for the Delta IV-M, -M+ (4,2), -M+ (5,2), -M+ (5,4), and -H vehicles, respectively.

**4.2.3.2 Combined Loads.** Dynamic excitations, occurring predominantly during liftoff and transonic periods of Delta IV launch vehicle flights, are superimposed on steady-state accelerations to produce combined accelerations that must be used in the spacecraft structural design. The combined spacecraft accelerations are a function of launch vehicle characteristics as well as spacecraft dynamic characteristics and mass properties. The spacecraft design limit-load factors and corresponding fundamental frequencies are presented in Table 4-5. The design load factors for various types of Delta IV launch vehicles are shown in Figures 4-23, 4-24, and 4-25. For spacecraft that weigh less than that noted in Table 4-5, the quasi-static load factors may be higher. Please contact Delta Launch Services for more information.

Customers are required to specify an accurate definition of the physical location of all points on the payload that are within 51 mm (2.0 in.) of the identified static envelope. This information is

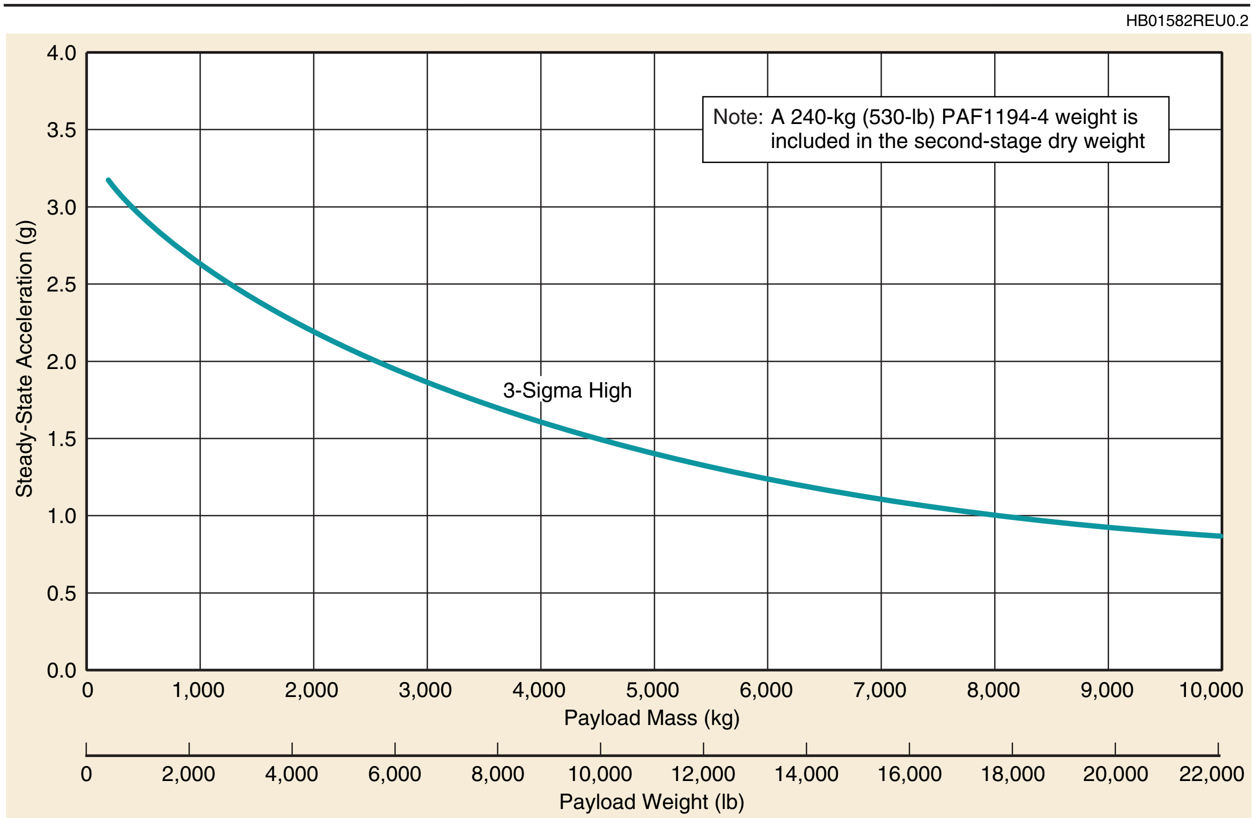


**Figure 4-18. Delta IV Medium Axial Steady-State Acceleration at Second-Stage Cutoff**

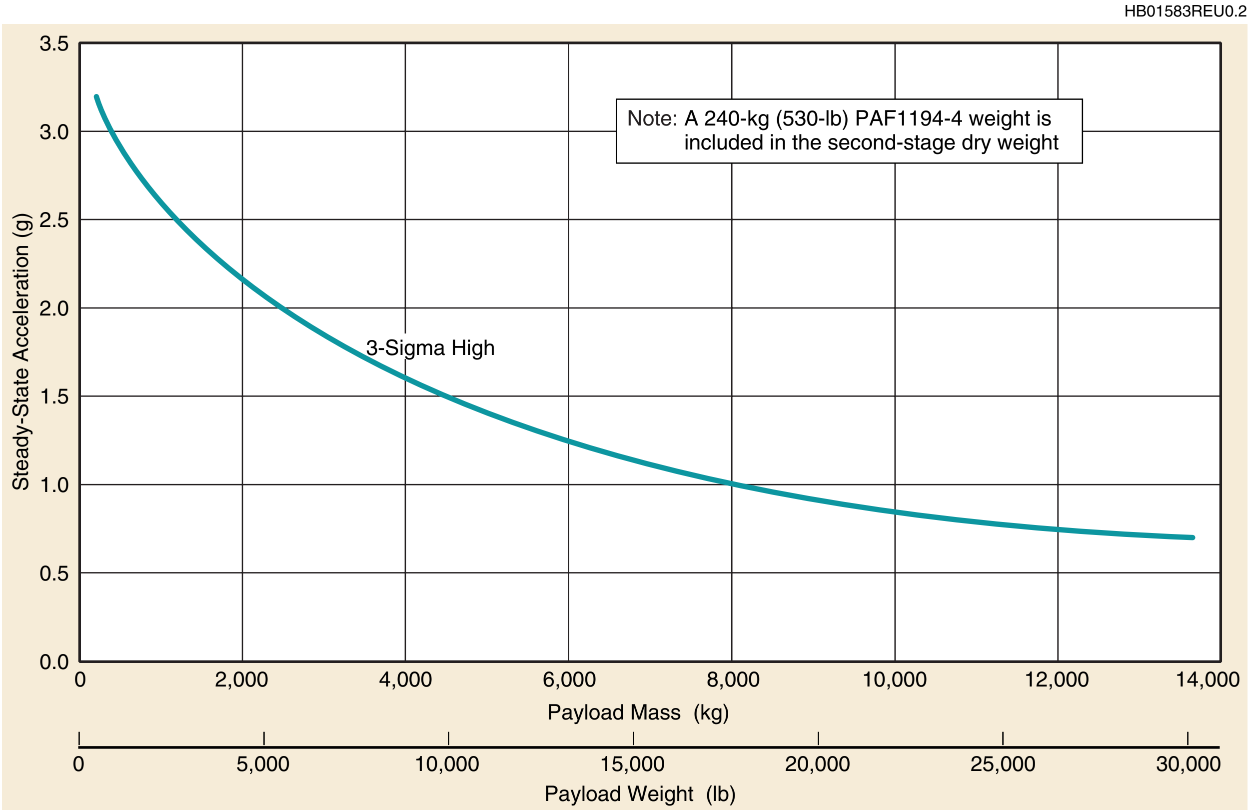


**Figure 4-19. Delta IV Medium-Plus (4,2) Axial Steady-State Acceleration at Second-Stage Cutoff**

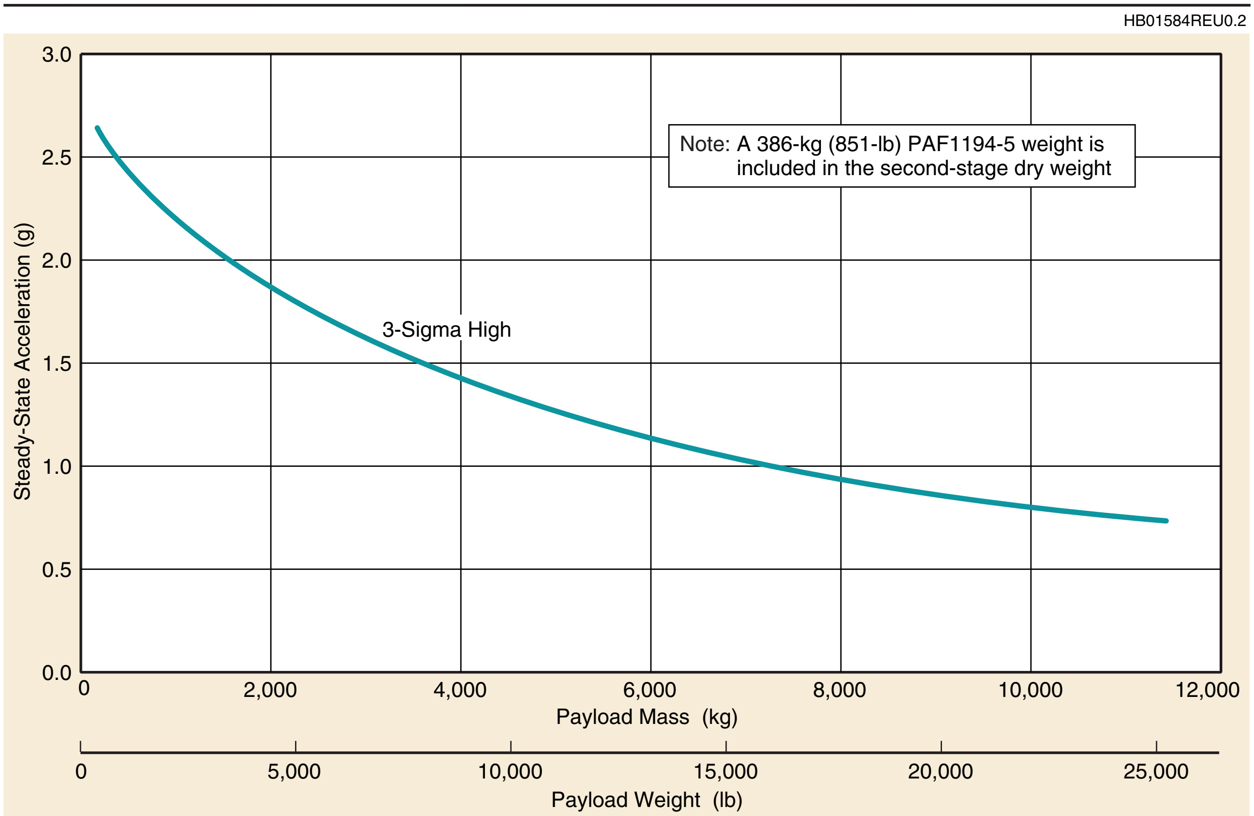


**Figure 4-20. Delta IV Medium-Plus (5,2) Axial Steady-State Acceleration at Second-Stage Cutoff**

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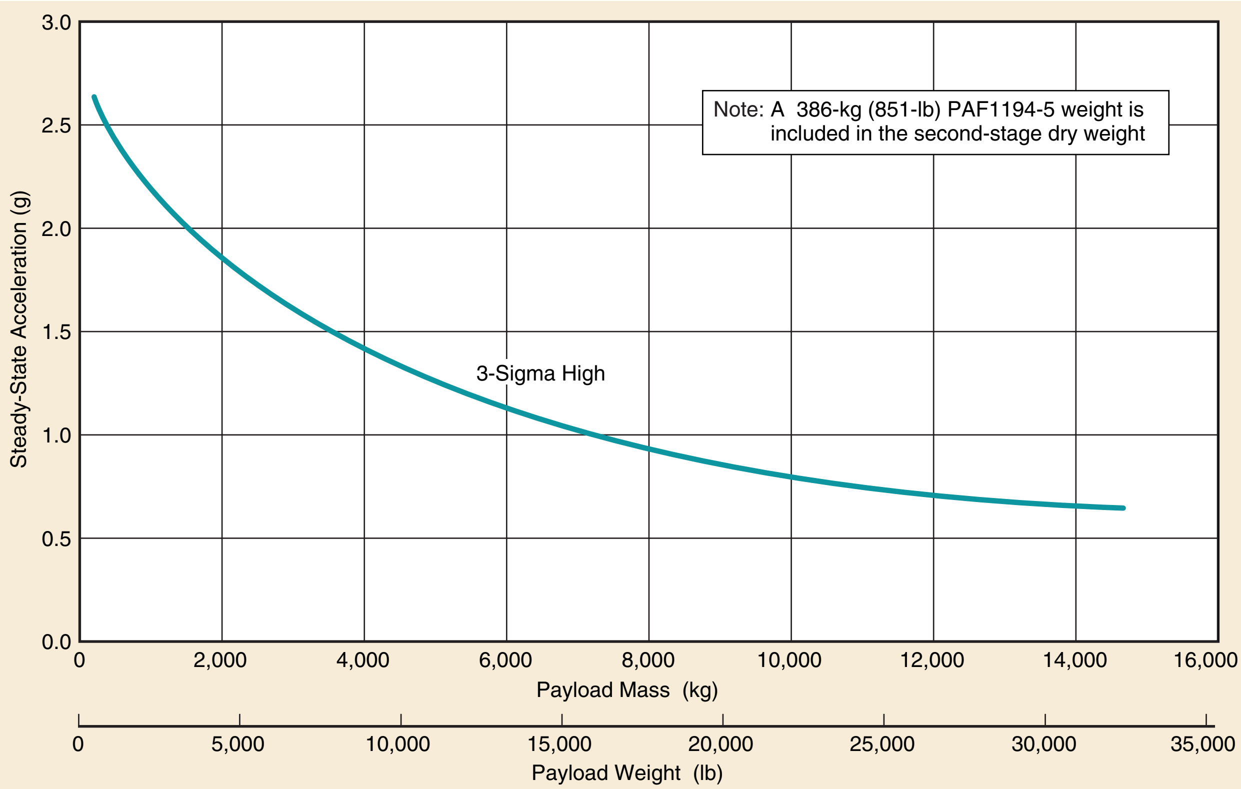


**Figure 4-21. Delta IV Medium-Plus (5,4) Axial Steady-State Acceleration at Second-Stage Cutoff**

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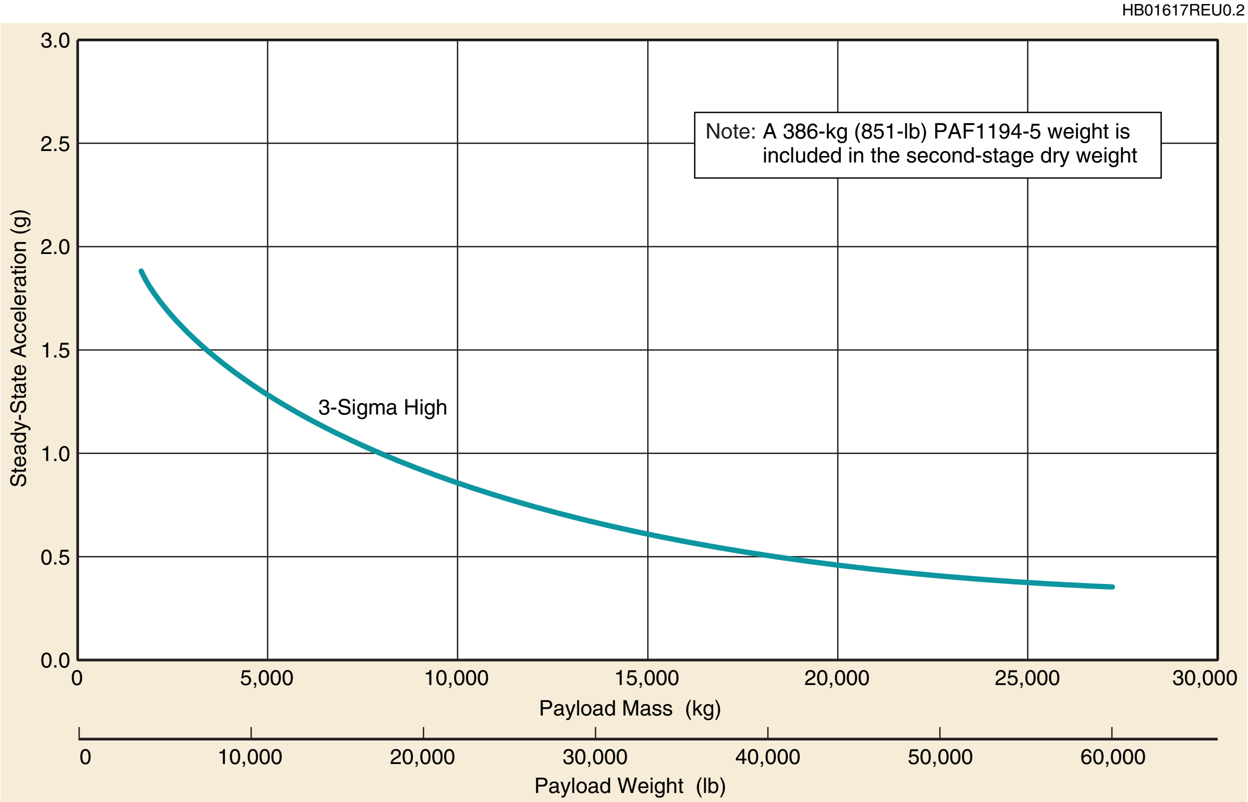


**Figure 4-22. Delta IV Heavy Axial Steady-State Acceleration at Second-Stage Cutoff**

**Table 4-5. Spacecraft Minimum Frequency and Quasi-Static Load Factors**

| Static envelope requirements | | | | | Maximum lateral | | Maximum axial | |
|---|---|---|---|---|---|---|---|---|
| LV type | Overall payload fairing length (m/ft) | Minimum axial frequency (Hz) | Minimum lateral frequency (Hz) | Minimum weight (kg/lb) | Maximum axial (g) | Maximum lateral (g) | Maximum* axial (g) | Maximum lateral (g) |
| Delta IV Medium | 11.7/38.5 | 27 | 10 | 907 (2000) | See Figure 4-23 | | | |
| Delta IV Medium-Plus (4,2) | 11.7/38.5 | 27 | 10 | 2721 (6000) | See Figure 4-23 | | | |
| Delta IV Medium-Plus (5,2) | 14.3/47 | 27 | 10 | 2721 (6000) | See Figure 4-24 | | | |
| Delta IV Medium-Plus (5,4) | 14.3/47 | 27 | 10 | 4989 (11,000) | See Figure 4-24 | | | |
| Delta IV Heavy | 19.8/62.7 | 30 | 8 | 6577 (14,500) | See Figure 4-25 | | | |
| Delta IV Heavy Dual-Manifest | 22.4/73.5 | 30 | 8 | 6577** (14,500) | See Figure 4-25 | | | |

*Current projection; lower customer axial requirements may be accommodated through coordination with Delta Launch Services.
**Combined payload weight.

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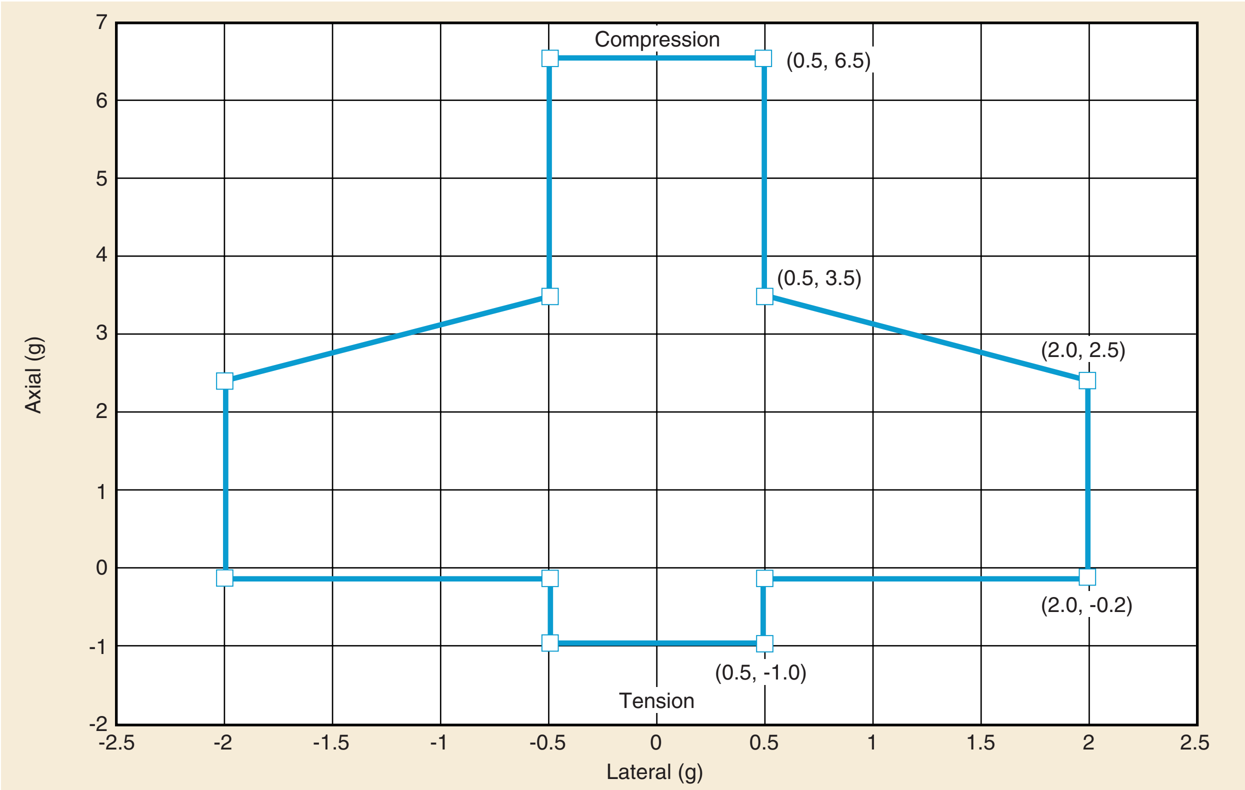


**Figure 4-23. Delta IV Medium and Medium-Plus (4,2) Design Load Factors**

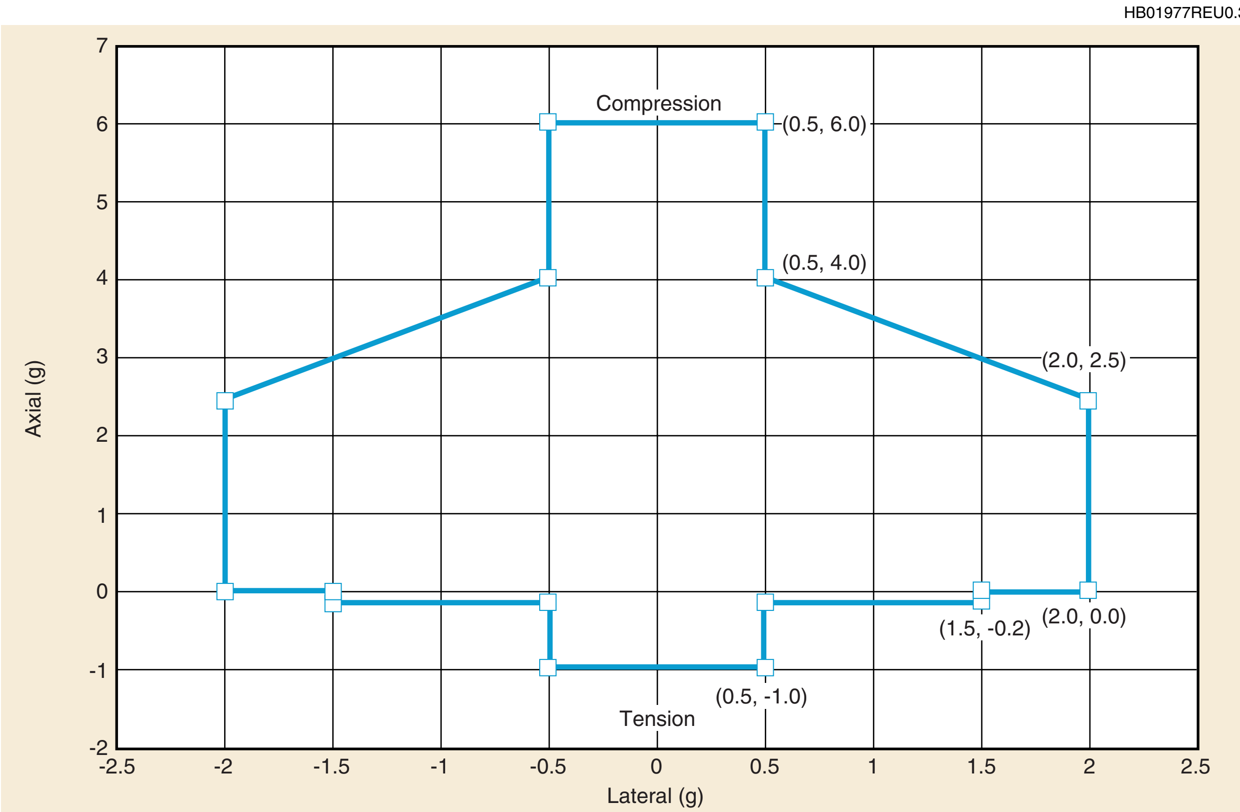


**Figure 4-24. Delta IV Medium-Plus (5,2) and Medium-Plus (5,4) Design Load Factors**

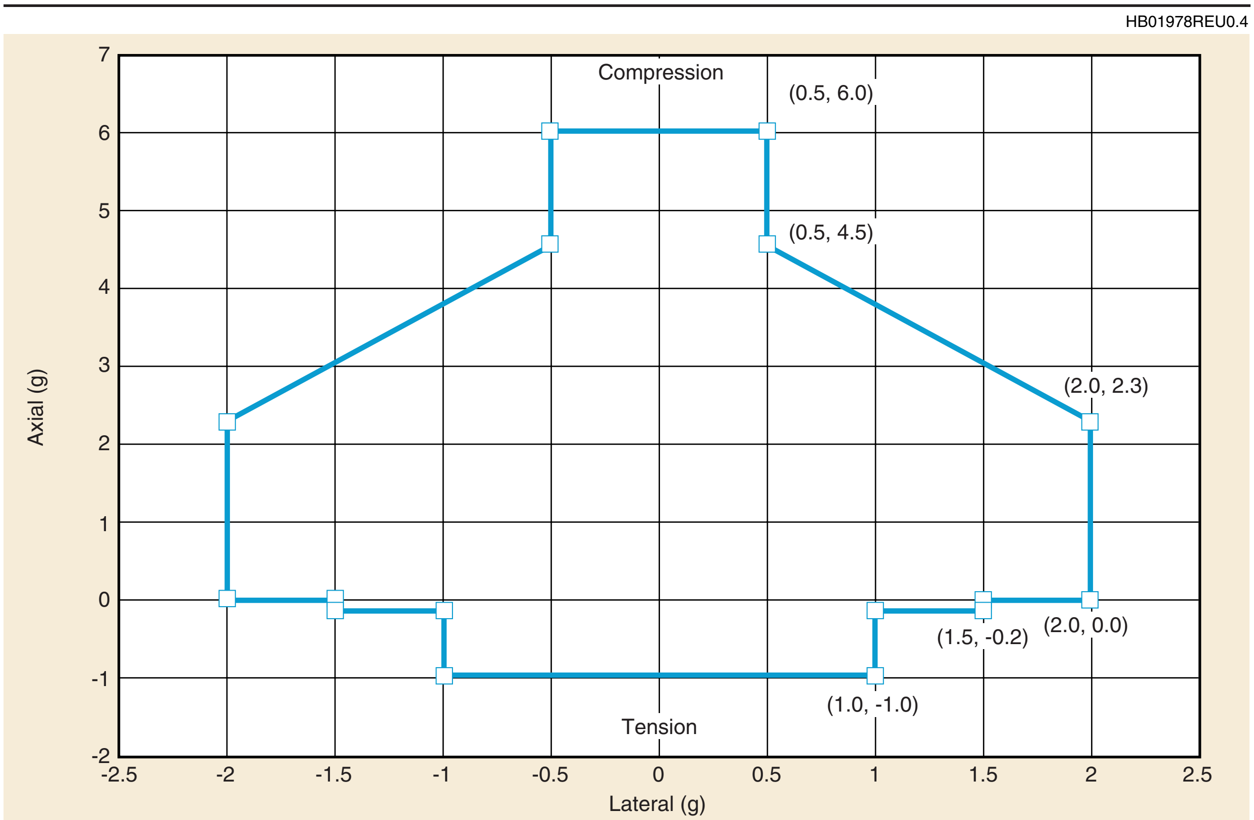


**Figure 4-25. Delta IV Heavy Design Load Factors**

required to verify no contact between the payload and the fairing as a result of dynamic deflections. To prevent dynamic coupling between low-frequency launch vehicle and payload modes, the stiffness of the payload structure should produce fundamental frequencies above the levels stated in Table 4-5 for the corresponding launch vehicles. These frequencies are for a payload hard-mounted at the separation plane without compliance from the PAF and associated separation system accounted for or, in the case of multiple-manifested payloads, at the dispenser-to-launch-vehicle interface. Secondary structure mode frequencies should be above 35 Hz to prevent undesirable coupling with launch vehicle modes and/or large fairing-to-payload relative dynamic deflections. For very flexible payloads, the combined accelerations and subsequent design load factors could be higher than shown; users should consult the Delta Launch Services so that appropriate analyses can be performed to better define loading conditions.

**4.2.3.3 Acoustic Environment.** The maximum acoustic environment experienced by the payload occurs during liftoff and transonic flight. The payload acoustic environment is a function of the configuration of the launch vehicle, the fairing, the fairing acoustic blankets, and the payload. Table 4-6 identifies the figures that define the payload acoustic environment for the four versions of the Delta IV launch vehicle system. The acoustic levels are presented as one-third octave-band sound pressure levels (dB, ref: $2 \times 10^{-5}$ N/m$^2$) versus one-third octave band center frequency. These levels apply to the blanketed section of the fairing and represent a 95th percentile space average flight environment for a fairing with a 50% confidence prediction and a 60% payload volume fill effect. A larger payload may increase the acoustic environments shown in Figures 4-26, 4-27, 4-28, and 4-29. Customers should contact Delta Launch Services to coordinate any payload acoustic requirements below the levels shown.

When the size, shape, and overall dimensions of a spacecraft are defined, a mission-specific analysis can be performed to define the specific payload's acoustic environment. The acoustic environment produces the dominant high-frequency random vibration responses in the payload. Thus, a properly performed acoustic test is the best simulation of the acoustically induced random vibration environment (see Section 4.2.4.2). No significant high-frequency random vibration inputs at the PAF interface are generated by Delta IV launch vehicles; consequently, a Delta IV PAF interface random vibration environment is not specified.

**Table 4-6. Spacecraft Acoustic Environment Figure Reference**

| Delta IV launch vehicle configuration | Mission type | Fairing configuration | Space vehicle acoustic environment |
|---|---|---|---|
| Delta IV Medium, Medium-Plus | 2-stage | 4-m composite | See Figure 4-26 |
| Delta IV Medium-Plus | 2-stage | 5-m composite | See Figure 4-27 |
| Delta IV Heavy | 2-stage | 5-m composite | See Figure 4-28 |
| Delta IV Heavy | 2-stage | 5-m metallic | See Figure 4-29 |

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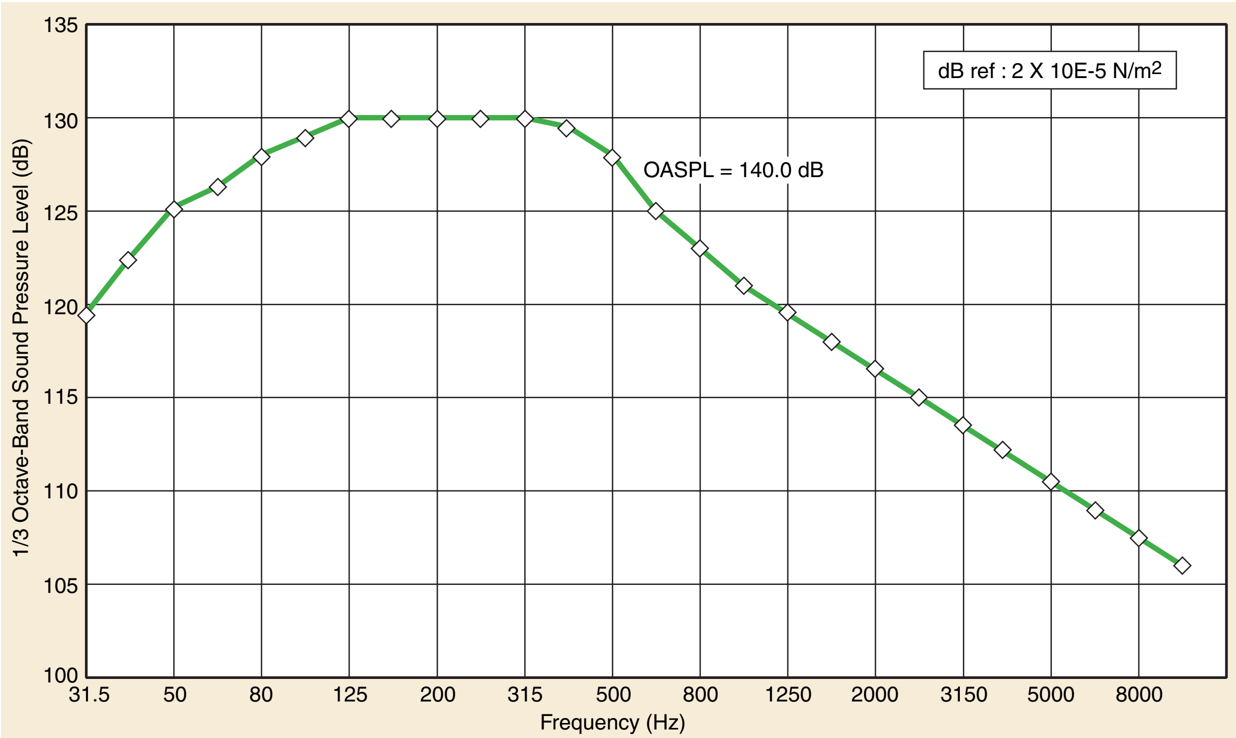


**Figure 4-26. Delta IV-M and Delta IV-M+ (4-m Composite Fairing) Internal Payload Acoustics Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included**

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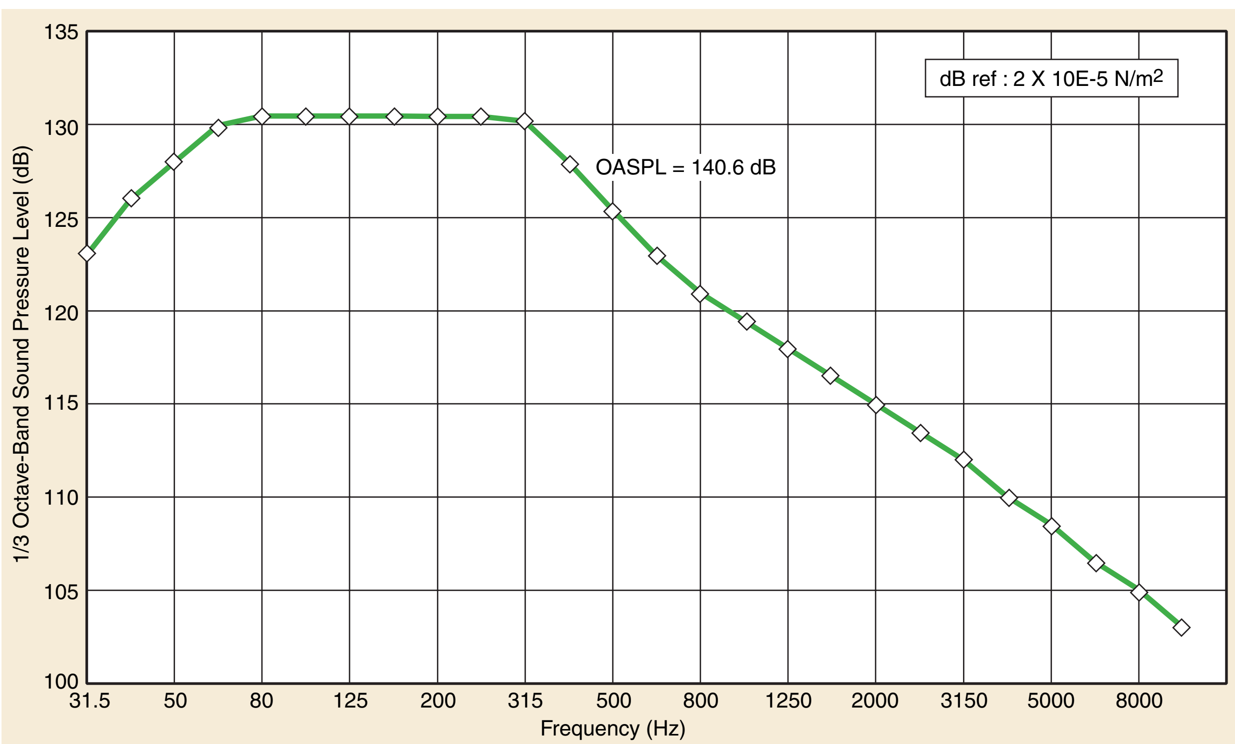


**Figure 4-27. Delta IV-M+ (5-m Composite Fairing) Internal Payload Acoustics Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included**

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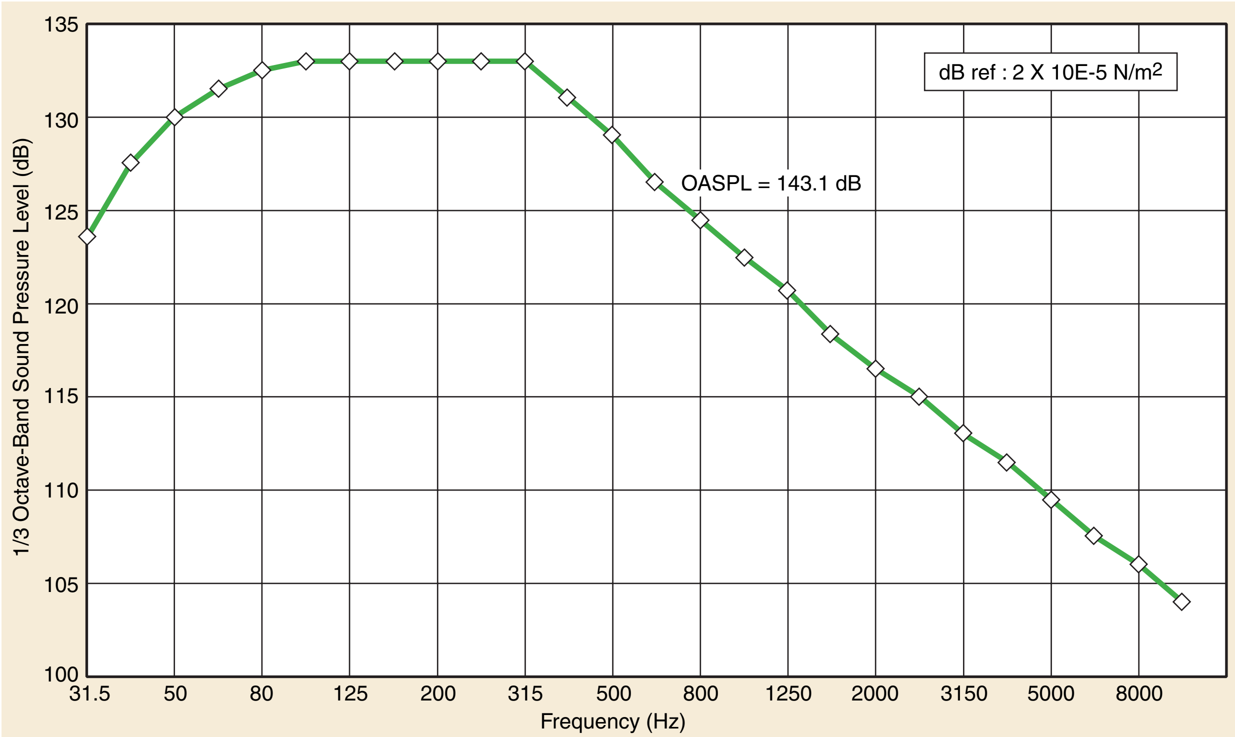


**Figure 4-28. Delta IV Heavy (5-m Composite Fairing) Internal Payload Acoustics Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included**

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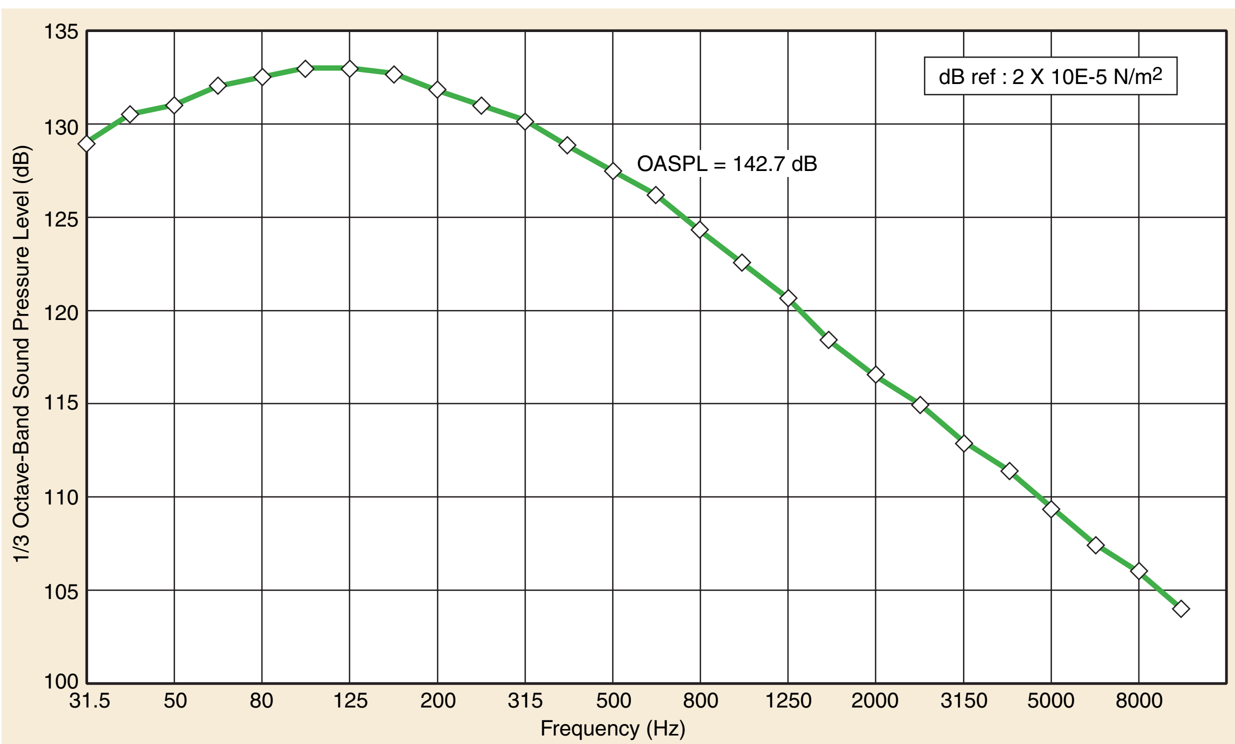


**Figure 4-29. Delta IV Heavy (5-m Metallic Fairing) Internal Payload Acoustics Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included**

**4.2.3.4 Sinusoidal Vibration Environment.** The payload will experience sinusoidal vibration inputs as a result of the launch, due to numerous transients and oscillatory flight events during ascent. The maximum predicted flight level sinusoidal vibration inputs, which are the same for all Delta IV launch vehicle configurations, are defined in Table 4-7 at the spacecraft separation plane. These predicted sinusoidal vibration levels provide general envelope low-frequency flight dynamic events such as liftoff transients, transonic/max-Q oscillations, main engine cutoff (MECO) transients, pre-MECO sinusoidal oscillations, and second-stage events.

**Table 4-7. Delta IV Sinusoidal Vibration Levels**

| Axis | Frequency (Hz) | Maximum flight levels |
|---|---|---|
| Thrust | 5 to 6.2<br>6.2 to 100 | 1.27 cm (0.5 in.) double amplitude<br>1.0 g (zero to peak) |
| Lateral | 5 to 100 | 0.7 g (zero to peak) |

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The sinusoidal vibration levels in Table 4-7 are not intended for use in the design of spacecraft primary structure. Load factors for spacecraft primary structure design are specified in Table 4-5.

The sinusoidal vibration levels should be used in conjunction with the results of the coupled dynamic loads analysis to aid in the design of spacecraft secondary structure (e.g., solar arrays, antennae, appendages) that may experience dynamic loading due to coupling with Delta IV launch vehicle low-frequency dynamic oscillations. Notching of the sinusoidal vibration input levels at spacecraft fundamental frequencies may be required during testing and should be based on the results of the launch vehicle coupled dynamic loads analysis (see Section 4.2.4.3).

**4.2.3.5 Shock Environment.** The maximum shock environment typically occurs during spacecraft separation from the Delta IV launch vehicle and is a function of the separation system configuration. The customer has the option to provide their own separation system. High-frequency shock levels at the payload/launch vehicle interface due to other shock events, such as first- and second-stage separation and fairing separation, are typically exceeded by spacecraft separation shock environment.

The data provided are intended to aid in the design of spacecraft components and secondary structures that may be sensitive to high-frequency pyrotechnic shock. Typical of this type of shock, the level dissipates rapidly with distance and the number of joints between the shock source and the component of interest. A properly performed system-level shock test is the best simulation of the high-frequency pyrotechnic shock environment (Section 4.2.4.4)

**4.2.3.5.1 Payload Attach Fitting Shock Environments.** For customer-supplied separation system interface, the maximum allowable payload-induced shock that the launch vehicle can withstand is shown in Figure 4-30 for all launch vehicle configurations.

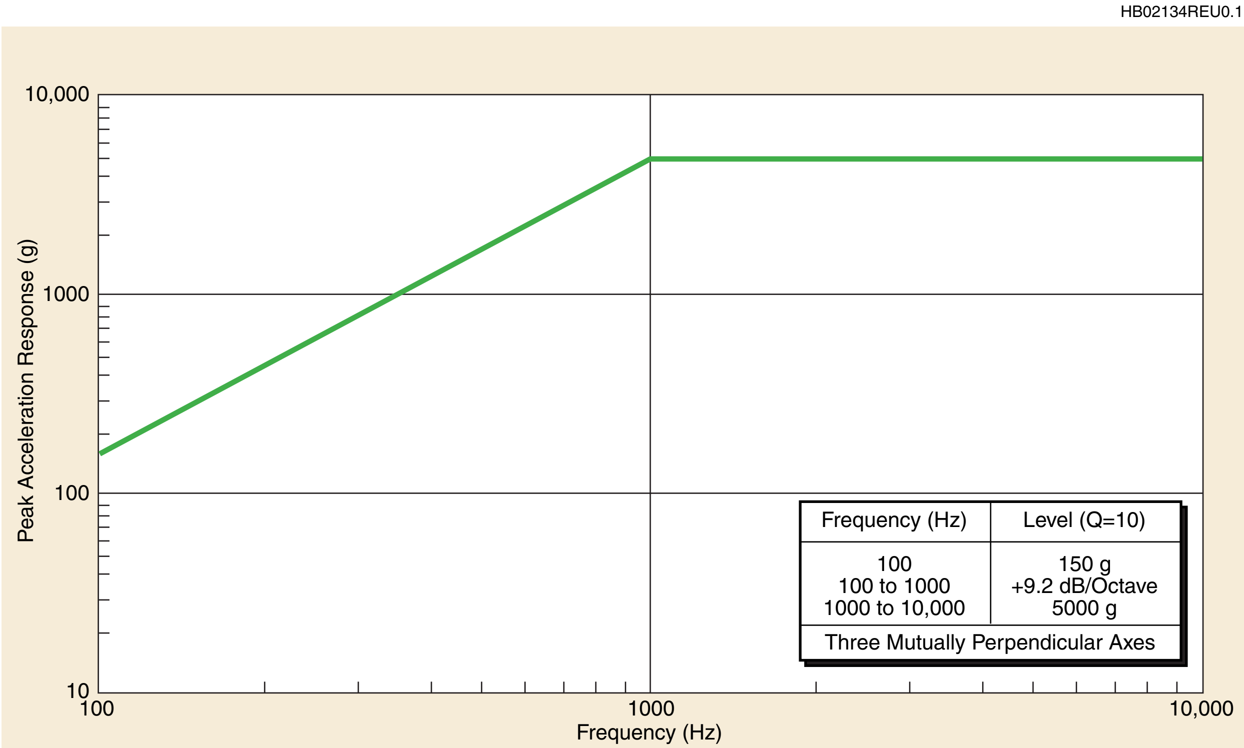


**Figure 4-30. Maximum Payload-Induced Shock Level to Launch Vehicle (95th Percentile, 50% Confidence)**

Table 4-8 identifies the figures that define the launch-vehicle-induced PAF interface shocks for all available Delta IV PAF configurations. The interface shock levels represents a 95th percentile environment with a 50% confidence prediction (P95/50) for all launch-vehicle-induced shock events. Users should contact Delta Launch Services to coordinate any payload shock requirements below the levels shown in Figures 4-31, 4-32, 4-33, and 4-34.

### 4.2.4 Spacecraft Qualification and Acceptance Testing

Outlined here are a series of environmental system-level qualification, acceptance, and protoflight tests for spacecraft launched on Delta IV launch vehicles. All of the tests and subordinate requirements in this section are recommendations, not requirements, except for Section 4.2.4.1, Structural Load Testing. If the spacecraft primary structural capability is to be demonstrated by test, this section becomes a requirement. If the spacecraft primary structural capability is to be demonstrated by analysis (minimum factors of 1.6 on yield and 2.0 on ultimate), Section 4.2.4.1 is only a recommendation. These tests are generalized to encompass numerous payload

**Table 4-8. PAF Interface Shock Environment Figure Reference**

| Payload attach fitting | Interface type | Payload attach fitting interface environment |
|---|---|---|
| 1194-4, -5 | 1194-mm (47-in.) dia clampband<br>31-kN (7000-lb) preload | See Figure 4-31 |
| 1575-4, -5 | Bolted interface | See Figure 4-32 |
| 1666-4, -5 | 1666-mm (66-in.) dia clampband<br>31-kN (7000-lb) preload | See Figure 4-33 |
| 4394-5 | Bolted interface | See Figure 4-34 |

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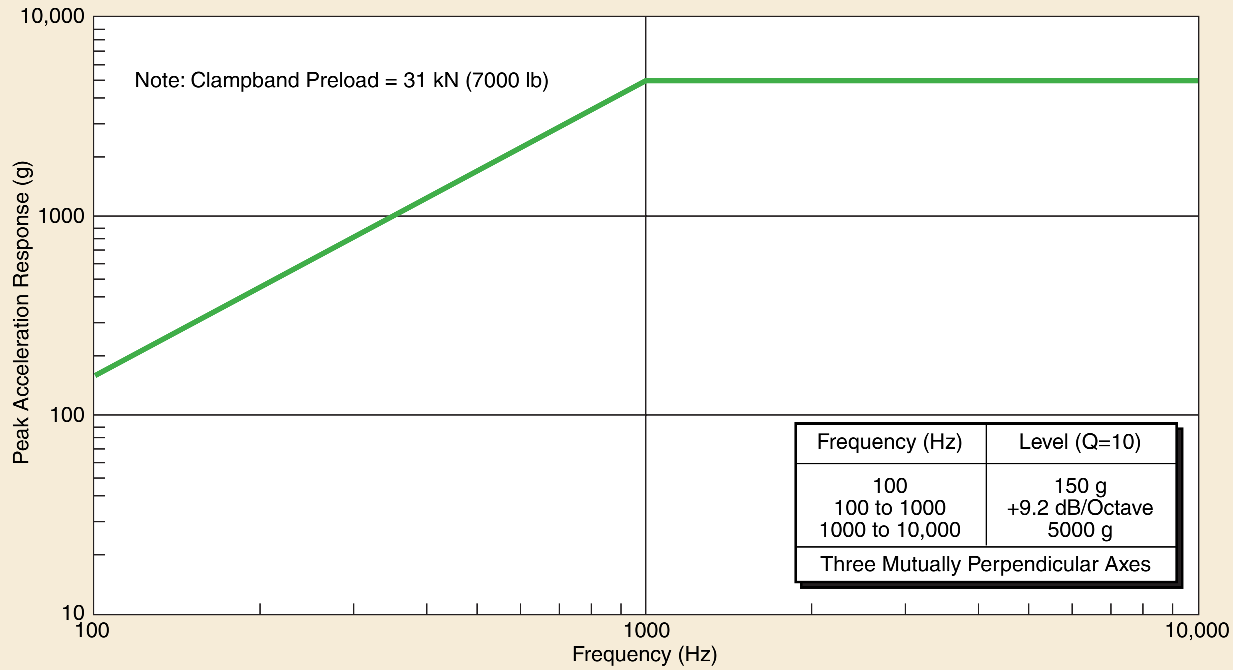


**Figure 4-31. Launch-Vehicle-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1194-4, -5 Payload Attach Fittings**

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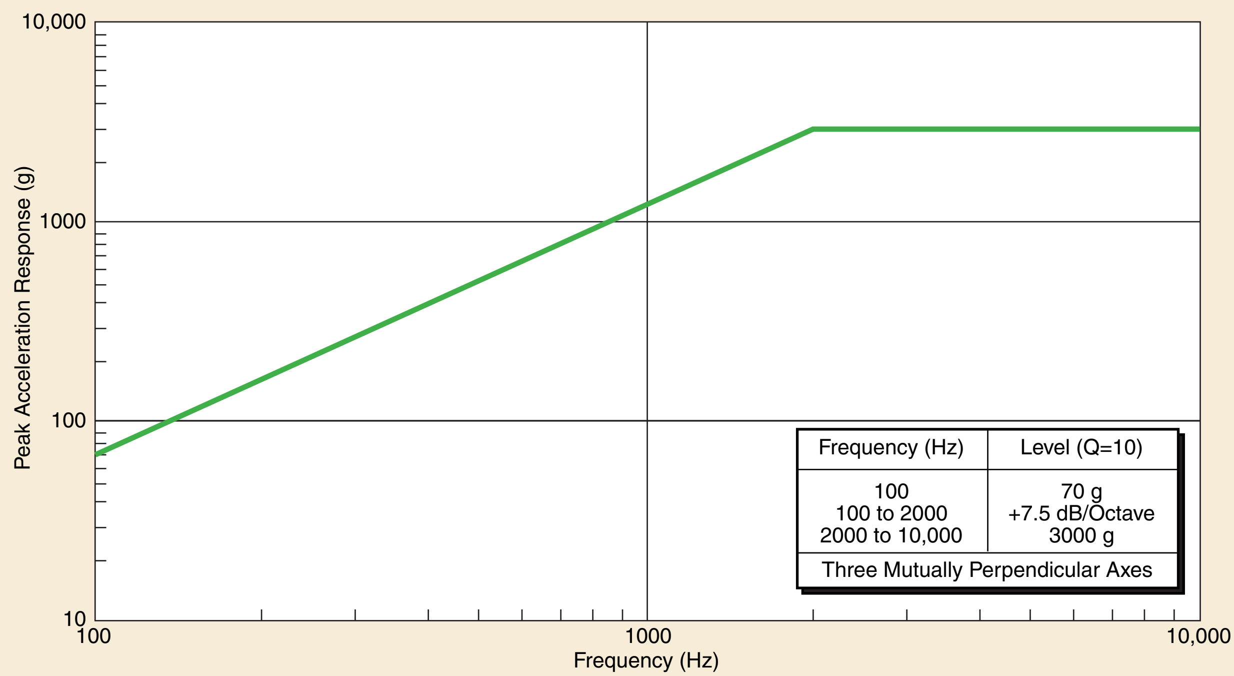


**Figure 4-32. Launch-Vehicle-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1575-4, -5 Payload Attach Fittings**

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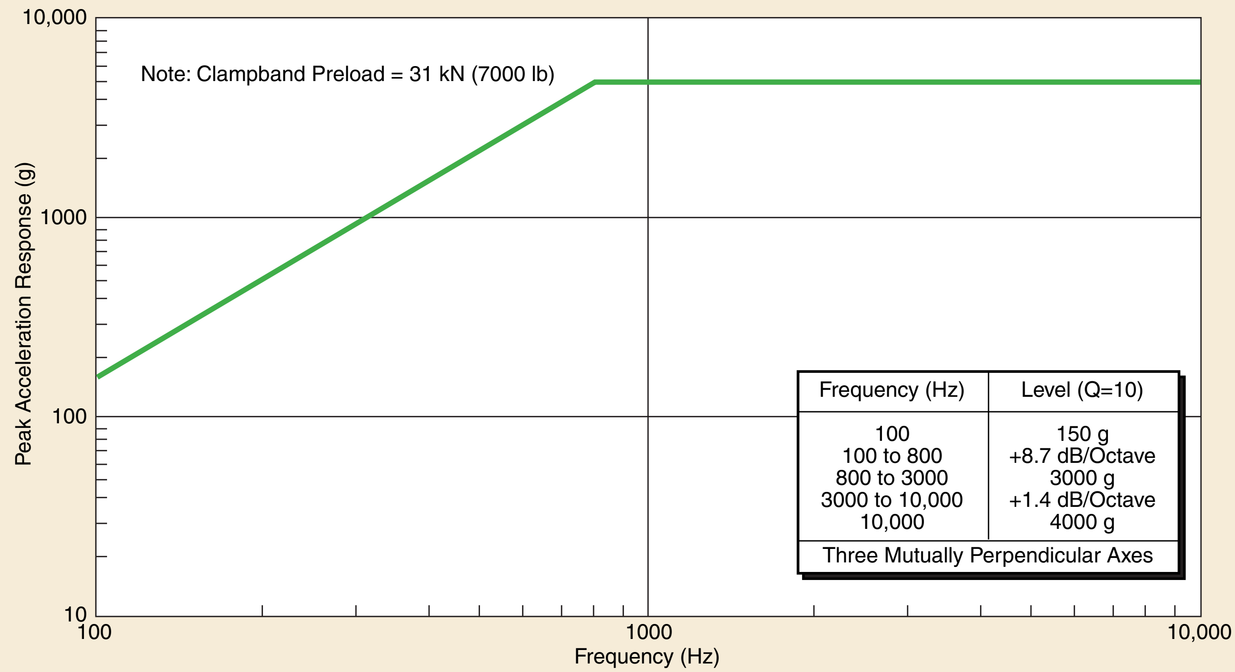


| Frequency (Hz) | Level (Q=10) |
|---|---|
| 100 | 150 g |
| 100 to 800 | +8.7 dB/Octave |
| 800 to 3000 | 3000 g |
| 3000 to 10,000 | +1.4 dB/Octave |
| 10,000 | 4000 g |
| Three Mutually Perpendicular Axes | |

**Figure 4-33. Launch-Vehicle-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1666-4, -5 Payload Attach Fittings**

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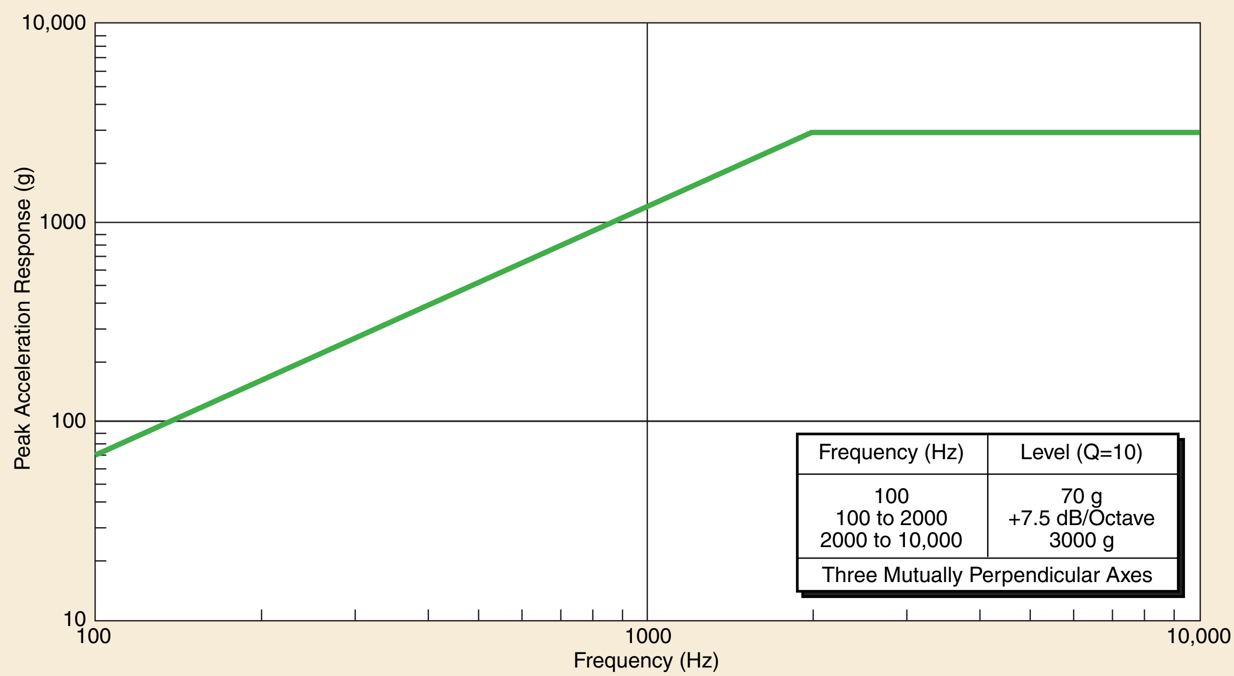


| Frequency (Hz) | Level (Q=10) |
|---|---|
| 100 | 70 g |
| 100 to 2000 | +7.5 dB/Octave |
| 2000 to 10,000 | 3000 g |
| Three Mutually Perpendicular Axes | |

**Figure 4-34. Launch-Vehicle-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—4394-5 Payload Attach Fitting**

configurations. For this reason, managers of each payload project should critically evaluate its specific requirements and develop detailed, tailored test specifications. Coordination with Delta Launch Services during the development of spacecraft test specifications is encouraged to ensure the adequacy of the spacecraft test approach.

The qualification test levels presented in this section are intended to ensure that the spacecraft possesses adequate design margin to withstand the maximum expected Delta IV dynamic environmental loads, even with minor weight and design variations. The acceptance test levels are intended to verify adequate spacecraft manufacture and workmanship by subjecting the payload to maximum expected flight environments. The protoflight test approach is intended to combine verification of design margin and adequacy of spacecraft manufacture and workmanship by subjecting the payload to protoflight test levels that are equal to qualification test levels with reduced durations.

**4.2.4.1 Structural Load Testing.** Structural load testing is performed by the customer to demonstrate the design integrity of the primary structure of the spacecraft. These loads are based on worst-case conditions anticipated. Maximum flight loads will be increased by a factor of 1.25 to determine qualification test loads.

A test PAF is required to provide proper load distribution at the payload interface. The payload user shall consult Delta Launch Services before developing the structural load test plan and shall obtain concurrence for the test load magnitude to ensure that the PAF is not stressed beyond its load-carrying capability.

Spacecraft combined-loading qualification testing is accomplished by a static load test. Generally, static load tests can be readily performed on structures with easily defined load paths.

**4.2.4.2 Acoustic Testing.** The maximum flight level acoustic environments defined in Section 4.2.3.3 are increased by 3 dB for spacecraft acoustic qualification and protoflight testing. The acoustic test duration is 120 sec for qualification testing and 60 sec for protoflight testing. For spacecraft acoustic acceptance testing, the acoustic test levels are equal to the maximum flight level acoustic environments defined in Section 4.2.3.3. The acoustic acceptance test duration is 60 sec. The acoustic qualification, acceptance, and protoflight test levels for the Delta IV launch vehicle configurations are defined in Table 4-9.

The acoustic test tolerances are +4 dB and -2 dB from 50 Hz to 2000 Hz. Above and below these frequencies the acoustic test levels should be maintained as close to the nominal test levels as possible within the limitations of the test facility. The overall sound pressure level (OASPL) should be maintained within +3 dB and -1 dB of the nominal overall test level. Customers should contact Delta Launch Services to coordinate any spacecraft acoustic requirements below the test levels provided in Table 4-9.

**Table 4-9. Spacecraft Acoustic Test Levels**

| One-third octave-band center freq (Hz) | Acceptance levels | | | | Protoflight and qualification levels | | | |
|---|---|---|---|---|---|---|---|---|
| | Delta IV-M/-M+ 4-m PLF (dB) | Delta IV-M+ 5-m PLF (dB) | Delta IV-H isogrid PLF 5-m (dB) | Delta IV-H composite PLF 5-m (dB) | Delta IV-M/-M+ 4-m PLF (dB) | Delta IV-M+ 5-m PLF (dB) | Delta IV-H isogrid PLF 5-m (dB) | Delta IV-H composite PLF 5-m (dB) |
| 31.5 | 119.5 | 123.0 | 129.0 | 123.5 | 122.5 | 126.0 | 132.0 | 126.5 |
| 40 | 122.5 | 126.0 | 130.5 | 127.5 | 125.5 | 129.0 | 133.5 | 130.5 |
| 50 | 125.2 | 128.0 | 131.0 | 130.0 | 128.2 | 131.0 | 134.0 | 133.0 |
| 63 | 126.3 | 130.0 | 132.0 | 131.5 | 129.3 | 133.0 | 135.0 | 134.5 |
| 80 | 128.0 | 130.5 | 132.5 | 132.5 | 131.0 | 133.5 | 135.5 | 135.5 |
| 100 | 129.0 | 130.5 | 133.0 | 133.0 | 132.0 | 133.5 | 136.0 | 136.0 |
| 125 | 130.0 | 130.5 | 133.0 | 133.0 | 133.0 | 133.5 | 136.0 | 136.0 |
| 160 | 130.0 | 130.5 | 132.7 | 133.0 | 133.0 | 133.5 | 135.7 | 136.0 |
| 200 | 130.0 | 130.5 | 131.8 | 133.0 | 133.0 | 133.5 | 134.8 | 136.0 |
| 250 | 130.0 | 130.5 | 131.0 | 133.0 | 133.0 | 133.5 | 134.0 | 136.0 |
| 315 | 130.0 | 130.2 | 130.2 | 133.0 | 133.0 | 133.2 | 133.2 | 136.0 |
| 400 | 129.5 | 128.0 | 128.8 | 131.0 | 132.5 | 131.0 | 131.8 | 134.0 |
| 500 | 128.0 | 125.5 | 127.5 | 129.0 | 131.0 | 128.5 | 130.5 | 132.0 |
| 630 | 125.0 | 123.0 | 126.2 | 126.5 | 128.0 | 126.0 | 129.2 | 129.5 |
| 800 | 123.0 | 121.0 | 124.3 | 124.5 | 126.0 | 124.0 | 127.3 | 127.5 |
| 1000 | 121.0 | 119.5 | 122.5 | 122.5 | 124.0 | 122.5 | 125.5 | 125.5 |
| 1250 | 119.5 | 118.0 | 120.7 | 120.7 | 122.5 | 121.0 | 123.7 | 123.7 |
| 1600 | 118.0 | 116.5 | 118.3 | 118.3 | 121.0 | 119.5 | 121.3 | 121.3 |
| 2000 | 116.5 | 115.0 | 116.5 | 116.5 | 119.5 | 118.0 | 119.5 | 119.5 |
| 2500 | 115.0 | 113.5 | 115.0 | 115.0 | 118.0 | 116.5 | 118.0 | 118.0 |
| 3150 | 113.5 | 112.0 | 113.0 | 113.0 | 116.5 | 115.0 | 116.0 | 116.0 |
| 4000 | 112.0 | 110.0 | 111.5 | 111.5 | 115.0 | 113.0 | 114.5 | 114.5 |
| 5000 | 110.5 | 108.5 | 109.5 | 109.5 | 113.5 | 111.5 | 112.5 | 112.5 |
| 6300 | 109.0 | 106.5 | 107.5 | 107.5 | 112.0 | 109.5 | 110.5 | 110.5 |
| 8000 | 107.5 | 105.0 | 106.0 | 106.0 | 110.5 | 108.0 | 109.0 | 109.0 |
| 10000 | 106.0 | 103.0 | 104.0 | 104.0 | 109.0 | 106.0 | 107.0 | 107.0 |
| OASPL (dB) | 140.0 | 140.6 | 142.7 | 143.1 | 143.0 | 143.6 | 145.7 | 146.1 |
| Acceptance test duration | 60 sec | 60 sec | 60 sec | 60 sec | --- | --- | --- | --- |
| Protoflight test duration | --- | --- | --- | --- | 60 sec | 60 sec | 60 sec | 60 sec |
| Qualification test duration | --- | --- | --- | --- | 120 sec | 120 sec | 120 sec | 120 sec |

001950.4

**4.2.4.3 Sinusoidal Vibration Testing.** The maximum flight level sinusoidal vibration environments defined in Section 4.2.3.4 are increased by 3 dB (a factor of 1.4) for payload qualification and protoflight testing. For payload acceptance testing, the sinusoidal vibration test levels are equal to the maximum flight level sinusoidal vibration environments defined in Section 4.2.3.4. The sinusoidal vibration test levels at acceptance, protoflight, and qualification for all Delta IV launch vehicle configurations are defined in Tables 4-10, 4-11, and 4-12 at the spacecraft separation plane.

The spacecraft sinusoidal vibration qualification test consists of one sweep through the specified frequency range using a logarithmic sweep rate of 2 octaves per min. For spacecraft acceptance and protoflight testing, the test consists of one sweep through the specified frequency range

**Table 4-10. Sinusoidal Vibration Acceptance Test Levels**

| Axis | Frequency (Hz) | Acceptance test levels | Sweep rate |
|---|---|---|---|
| Thrust | 5 to 6.2<br>6.2 to 100 | 1.27 cm (0.5 in.) double amplitude<br>1.0 g (zero to peak) | 4 octaves/min |
| Lateral | 5 to 100 | 0.7 g (zero to peak) | 4 octaves/min |

0000593.1

**Table 4-11. Sinusoidal Vibration Protoflight Test Levels**

| Axis | Frequency (Hz) | Acceptance test levels | Sweep rate |
|---|---|---|---|
| Thrust | 5 to 7.4<br>7.4 to 100 | 1.27 cm (0.5 in.) double amplitude<br>1.4 g (zero to peak) | 4 octaves/min |
| Lateral | 5 to 6.2<br>6.2 to 100 | 1.27 cm (0.5 in) double amplitude<br>1.0 g (zero to peak) | 4 octaves/min |

0000594.2

**Table 4-12. Sinusoidal Vibration Qualification Test Levels**

| Axis | Frequency (Hz) | Acceptance test levels | Sweep rate |
|---|---|---|---|
| Thrust | 5 to 7.4<br>7.4 to 100 | 1.27 cm (0.5 in.) double amplitude<br>1.4 g (zero to peak) | 2 octaves/min |
| Lateral | 5 to 6.2<br>6.2 to 100 | 1.27 cm (0.5 in) double amplitude<br>1.0 g (zero to peak) | 2 octaves/min |

0000592.2

using a logarithmic sweep rate of 4 octaves per min. The sinusoidal vibration test input levels should be maintained within ±10% of the nominal test levels throughout the test frequency range.

When testing a spacecraft with a shaker in the laboratory, it is not within the current state of the art to duplicate at the shaker input the boundary conditions that actually occur in flight. This is notably evident in the spacecraft lateral axis, during test, when the shaker applies large vibratory forces to maintain a constant acceleration input level at the spacecraft fundamental lateral test frequencies. The response levels experienced by the spacecraft at these fundamental frequencies during test are usually much more severe than those experienced in flight. The significant lateral loading to the spacecraft during flight is usually governed by the effects of payload/launch vehicle dynamic coupling.

Where it can be shown by a payload/launch vehicle coupled dynamic loads analysis that the payload or PAF would experience unrealistic response levels during test, the sinusoidal vibration input level can be reduced (notched) at the fundamental resonances of the hard-mounted payload or PAF to more realistically simulate flight loading conditions. This has been accomplished in the lateral axis on many previous spacecraft by correlating one or several accelerometers mounted on the spacecraft to the bending moment at the PAF spacecraft separation plane. The bending moment is then limited by introducing a narrow-band notch into the sinusoidal vibration input program or by controlling the input by a servo system using a selected accelerometer on the payload as the limiting monitor. A redundant accelerometer is usually used as a backup monitor to prevent shaker runaway.

Boeing normally will conduct a payload/launch vehicle coupled dynamic loads analysis for various spacecraft configurations to define the maximum expected bending moment in flight at the spacecraft separation plane. In the absence of a specific dynamic analysis, the bending moment is limited to protect the PAF, which is designed for a wide range of payload configurations and weights. The payload user should consult Delta Launch Services before developing the sinusoidal vibration test plan for information on the payload/launch vehicle coupled dynamic loads analysis. In many cases, the notched sinusoidal vibration test levels are established from previous similar analyses.

**4.2.4.4 Shock Testing.** High-frequency pyrotechnic shock levels are very difficult to simulate mechanically on a shaker at the spacecraft system level. The most direct method for this testing is to use a Delta IV flight configuration PAF spacecraft separation system and PAF structure with functional ordnance devices. Payload qualification and protoflight shock testing are performed by installing the in-flight configuration of the PAF spacecraft separation system and activating the system twice. Spacecraft shock acceptance testing is similarly performed by activating the PAF spacecraft separation system once.

### 4.2.5 Dynamic Analysis Criteria and Balance Requirements

Typical payload separation attitude and rate dispersions are shown in Table 4-13. Dispersions are defined for each vehicle configuration and consist of all known error sources. Dispersions are affected by spacecraft mass properties and center of gravity (CG) offsets. Mission-specific attitude and rate dispersions are defined in the payload/expended stage separation analysis.

**4.2.5.1 Two-Stage Missions.** Two-stage missions use the capability of the second stage to provide terminal velocity, roll, final spacecraft orientation, and separation.

**4.2.5.1.1 Balance Requirements.** There are no specific static and dynamic balance constraints for the spacecraft. However, for both nonspinning and spinning spacecraft, the static

**Table 4-13. Typical Payload Separation Attitudes/Rates**

| Configuration | Spinning | PAF | Payload separation attitude and rate dispersions (3-$\sigma$ values) | |
|---|---|---|---|---|
| | | | Attitude (deg) | Rate (dps) |
| Two stage | No | 1194-5<br>1194-4<br>1575-4<br>1664-4<br>1664-5<br>1666-4<br>1666-5 | <0.70 | <2.0 (trans), <1.0 (roll) |
| | Up to 5 rpm (±1 deg/sec) | 1194-4 | <10.0 | <3.0 (transverse) |

Note: Enhanced attitude pointing capability for spinning missions is currently under study with a goal of achieving attitude pointing errors less than 1.75 deg.

imbalance directly influences the spacecraft angular rates at separation. When there is a separation tip-off rate constraint, the spacecraft cg offset must be coordinated with Boeing for evaluation. For spinning spacecraft, the dynamic balance directly influences the angular momentum vector pointing and centerline pointing. When there are spacecraft constraints on these parameters, the dynamic balance must be coordinated with Boeing for evaluation.

**4.2.5.1.2 Second-Stage Roll Rate Capability.** For some two-stage missions, the spacecraft may require a roll rate at separation. The Delta IV second stage can command roll rates up to 5 rpm (0.52 rad/sec) using control jets. Higher roll rates are also possible; however, accuracy is degraded as the rate increases. Roll rates higher than 5 rpm (0.52 rad/sec) must be assessed relative to specific spacecraft requirements.

# Section 5
# PAYLOAD INTERFACES

This section presents detailed descriptions of the interfaces between the payload and the Delta IV launch vehicle family. Our Delta IV payload interfaces are designed to meet present and future demands of the global satellite market. The Boeing Company uses a heritage design approach for its payload attach fittings (PAFs). Unique interface requirements can be accommodated by modifying existing designs as required. In addition, multiple-payload dispenser systems are also available. For further details, coordinate with Delta Launch Services (DLS).

## 5.1 HERITAGE DESIGN PHILOSOPHY

Delta IV payload attach fittings are based on heritage designs that have been developed and qualified by Boeing. This approach offers several advantages, primarily in reducing development time and costs for new attach fittings.

### 5.1.1 Structural Design

The Delta IV PAFs utilize a structural design developed and successfully qualified on the heritage Delta programs. This design has evolved from a demand for a lighter weight structure with minimal part count. Some of the key features:

- A high-modulus graphite-epoxy/foam core sandwich construction for the conic shell.
- One-piece aluminum rings at each end for interfaces to the second stage and payload.
- Efficient double-splice lap joints to join end rings to the conic shell.
- A high-modulus graphite-epoxy/foam core sandwich diaphragm structure that provides a barrier to the second stage.

This design is easily adapted to accommodate different interface diameters and payload sizes simply by extending or reducing the conic shell and sizing the sandwich structure and end-ring design. As a result, much of the secondary structure developed for one PAF is readily adaptable to another.

The PAF for the evolved expendable launch vehicle (EELV) 5-m metallic-fairing missions adopts a different heritage design. This PAF makes use of a heritage truss structure design developed and flown by Boeing Space Structures in Kent, Washington. The design's extensive use of advanced composite materials, lightweight materials, and bonded structures fits well with the key objectives for this particular PAF.

### 5.1.2 Mechanical Design

Boeing has extensive flight experience with both Marmon-type clampband and discrete bolted interface separation systems. Delta II and Delta III have developed and flown Marmon-type clampbands over a broad range of diameters: 229 mm (9 in.) to 1666 mm (66 in.). In addition, Delta II has successfully employed a separation bolt with release-nut system on various missions. For each type of interface, redundant pyrotechnic devices enable spacecraft separation from the Delta IV PAF. Separation is achieved through the actuation of separation springs; locations and quantities of these springs can be tailored to suit each customer's needs.

## 5.2 DELTA IV PAYLOAD ATTACH FITTINGS

The Delta IV program offers several PAFs for use with 4-m and 5-m payload fairings, as shown in Figures 5-1 and 5-2, respectively. Each PAF is designated by its payload interface diameter in millimeters, followed by a dash and the corresponding fairing diameter in meters. (The associated payload envelopes for the following PAFs are shown in Section 3, Figures 3-2, 3-3, 3-4, 3-5, 3-9,

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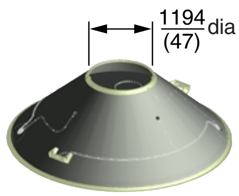
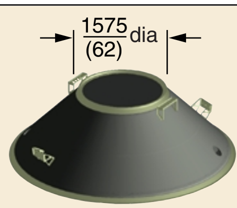
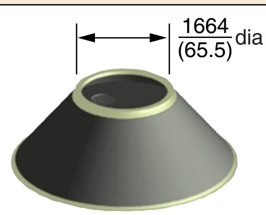
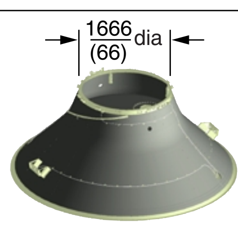
| | | | |
|---|---|---|---|
| Delta IV 937-4 PAF |   | 937 (37) dia clampband | Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact |
| Delta IV 1194-4 PAF |   | 1194 (47) dia clampband | Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact |
| Delta IV 1575-4 PAF |   | 121 bolts in a 1575 (62) dia bolt circle | 1575-mm (62.010-in.) bolted interface. EELV Medium Launch Vehicle/Intermediate Launch Vehicle MLV/ILV standard interface |
| Delta IV 1664-4 PAF |   | Four separation bolts in a 1664 (65.5) dia bolt circle | Four hard-point attachments, released by four redundantly initiated explosive nuts. Four differential springs to provide a tip-off rate |
| Delta IV 1666-4 PAF |   | 1666 (66) dia clampband | Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact |

mm
(in.)

EELV Standard Interface

**Figure 5-1. Delta IV 4-m Payload Attach Fittings**

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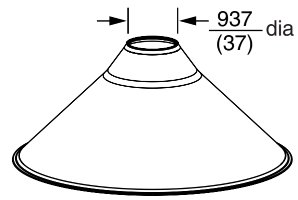
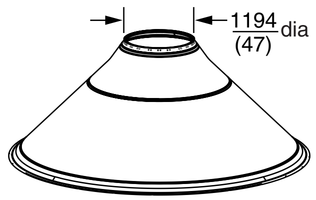
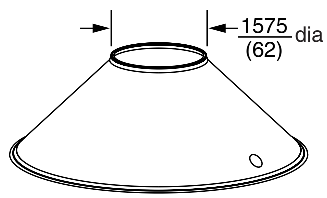
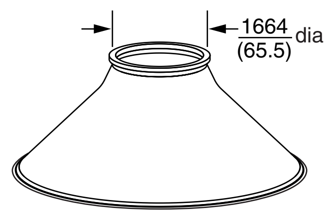
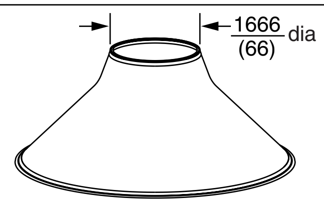
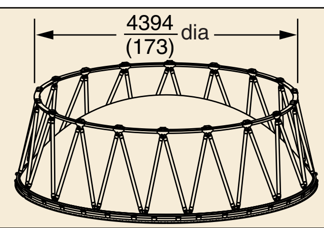
| | | | |
|---|---|---|---|
| Delta IV 937-5 PAF |  | 937 (37) dia clampband | Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact |
| Delta IV 1194-5 PAF |  | 1194 (47) dia clampband | Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact |
| Delta IV 1575-5 PAF |  | 121 bolts in a 1575 (62) dia bolt circle | 1575-mm (62.010-in.) bolted interface<br>EELV MLV/ILV standard interface |
| Delta IV 1664-5 PAF |  | Four separation bolts 1664 (65.5) dia bolt circle | Four hard-point attachments, released by four redundantly initiated explosive nuts. Four differential springs to provide a tip-off rate |
| Delta IV 1666-5 PAF |  | 1666 (66) dia clampband | Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact |
| Delta IV 4394-5 PAF |  | 72 bolts in a 4394 (173) dia bolt circle | 4394 (173-in.) bolted interface.<br>Standard only for 5-m metallic fairing |

mm
(in.)

EELV Standard Interface

**Figure 5-2. Delta IV 5-m Payload Attach Fittings**

3-10 and 3-11.) All PAFs are designed such that payload electrical interfaces and separation springs can be located to accommodate specific customer requirements. Selection of an appropriate PAF should be coordinated with Delta Launch Services as early as possible.

### 5.2.1 937-mm (37-in.) Payload Interface—937-4 and 937-5 PAFs

The 937-mm (37-in.) PAFs provide a Marmon-type clampband separation system with separation spring actuators similar to what has been developed on the Delta II program. Payload umbilical disconnects and separation spring assemblies are similar to what is used on other Delta IV PAFs. The 4-m composite fairing version, or 937-4 PAF, is shown in Figure 5-3, and the 5-m composite fairing version, or 937-5 PAF, is shown in Figure 5-4.

### 5.2.2 1194-mm (47-in.) Payload Interface—1194-4 and 1194-5 PAFs

Like the Delta IV 1666-4 and 1666-5 PAFs, the 1194-mm (47-in.) PAFs are derivatives of the Delta III 1194-4 payload attach fitting, providing a Marmon-type clampband separation system with separation spring actuators. Details of the 1194-4 PAF are provided in Figures 5-5 and 5-6, and details of the 1194-5 PAF are shown in Figure 5-7.

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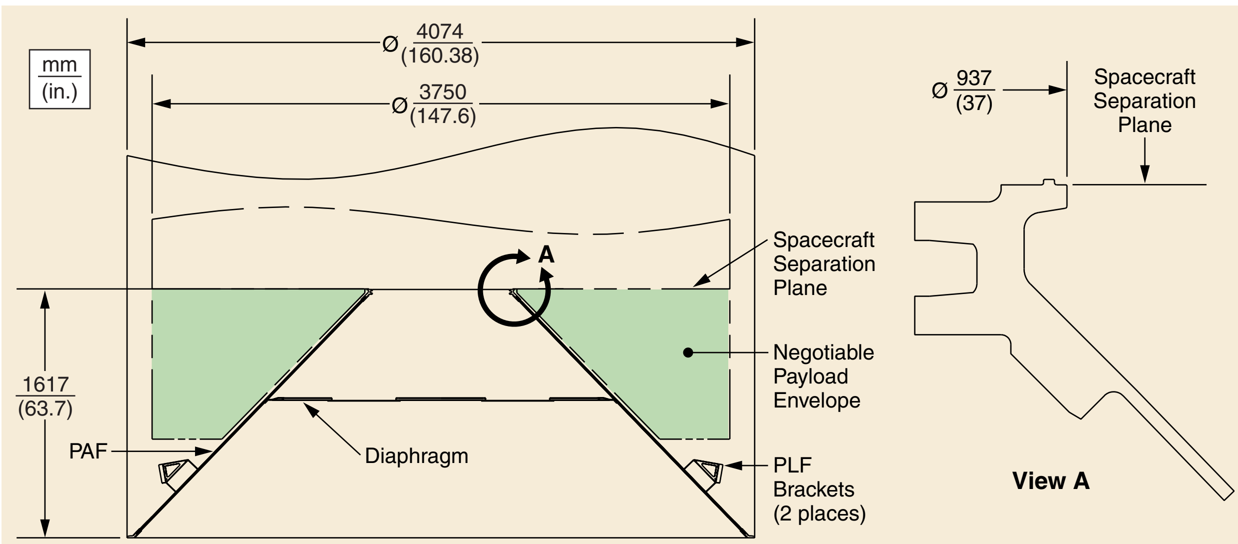


**Figure 5-3. Delta IV 937-4 PAF**

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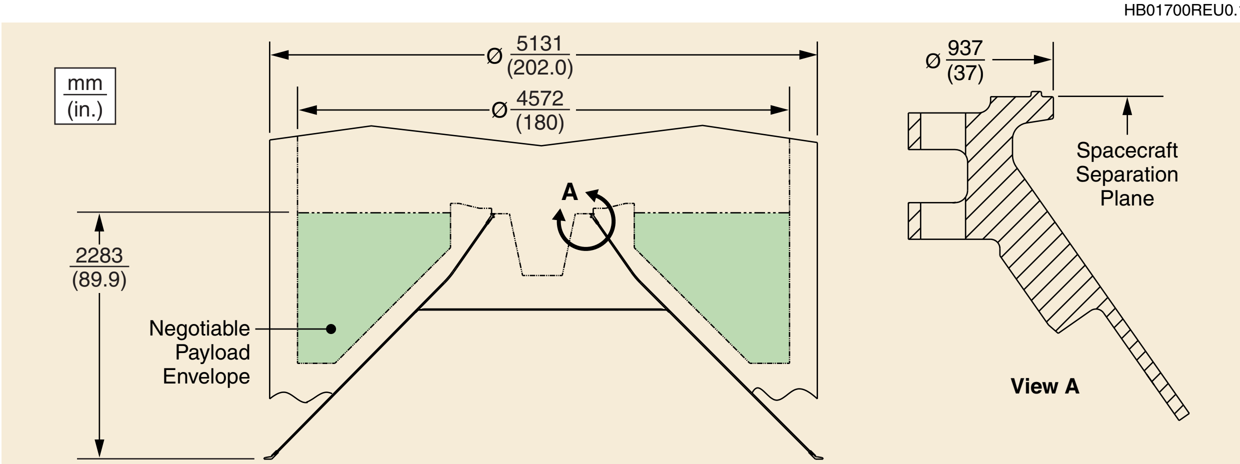


**Figure 5-4. Delta IV 937-5 PAF**

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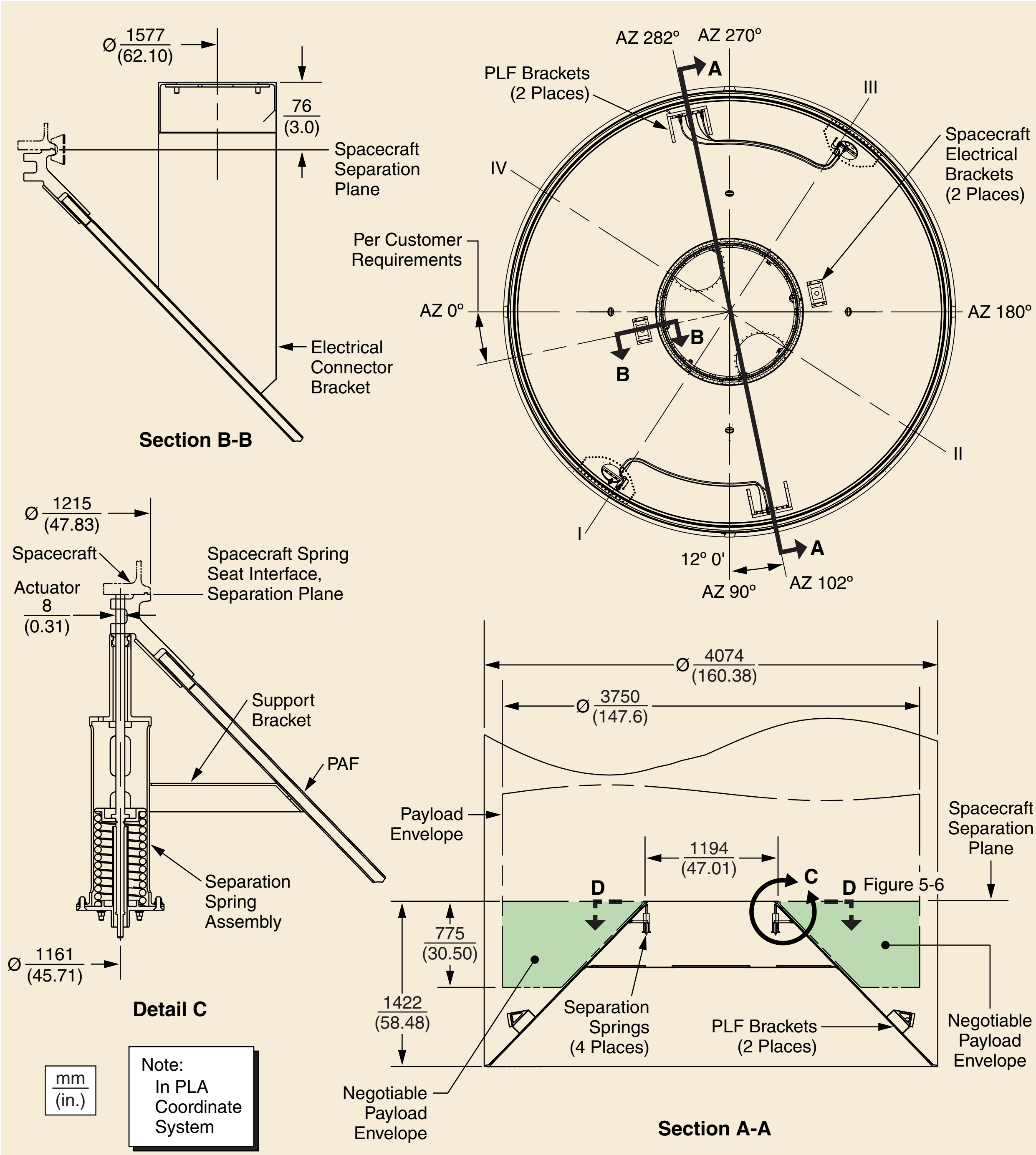


Figure 5-5. Delta IV 1194-4 PAF

### 5.2.3 1575-mm (62-in.) Payload Interface—1575-4 and 1575-5 PAFs

For the 4-m composite fairing, the 1575-4 PAF provides a standard 121-bolt mating interface to the payload at a 1575-mm (62.01 in.) dia. See Figures 5-8 and 5-9 for details. The 1575-5 PAF provides an identical interface for the 5-m composite fairing (Figure 5-10).

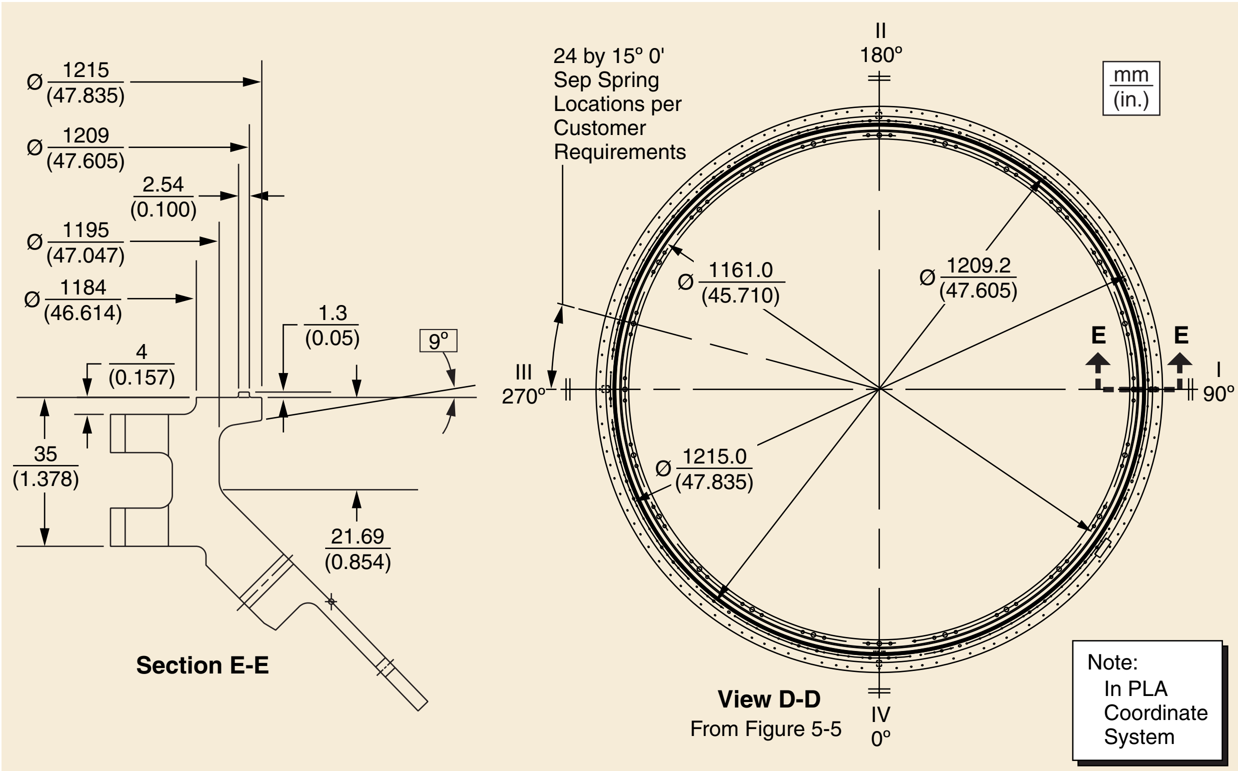


**Figure 5-6. Delta IV 1194-4 PAF**

For both the 4-m and 5-m composite fairings, a 1575-mm payload interface is offered; a larger 4394-mm interface is standard for 5-m metallic fairings. These fixed interfaces are intended to mate with a customer-provided separation system and/or payload adapter. Should the customer require Boeing to supply a separation system and/or mating adapter, this can be arranged by contacting Delta Launch Services.

### 5.2.4 1664-mm (66-in.) Payload Interface—1664-4 and 1664-5 PAFs

The 1664-mm PAFs provide a four-point, bolted separation system similar to what has been successfully flown on the Delta II program. The PAF also uses umbilical disconnects and separation spring assemblies similar to that of the 1666-mm interface. The 1664-4 PAF and 1664-5 PAF are shown in Figures 5-11 and 5-12, respectively.

### 5.2.5 1666-mm (66-in.) Payload Interface—1666-4 and 1666-5 PAFs

The Delta IV 1666-mm (66-in.) PAFs for both the 4-m and 5-m composite fairings are derivatives of the Delta III 1666-4 payload attach fitting and provide a Marmon-type clampband separation system with separation spring actuators. The Delta IV 1666-4 PAF is shown in Figures 5-13 and 5-14, and the 1666-5 PAF is shown in Figure 5-15.

### 5.2.6 4394-mm (173-in.) Payload Interface—4394-5 PAF

For the 5-m metallic fairing, the 4394-5 PAF uses an 18-point, 72-bolt interface pattern with a 4394-mm (173-in.) dia (Figure 5-16). The 4394-5 PAF uses a truss structure design (as opposed

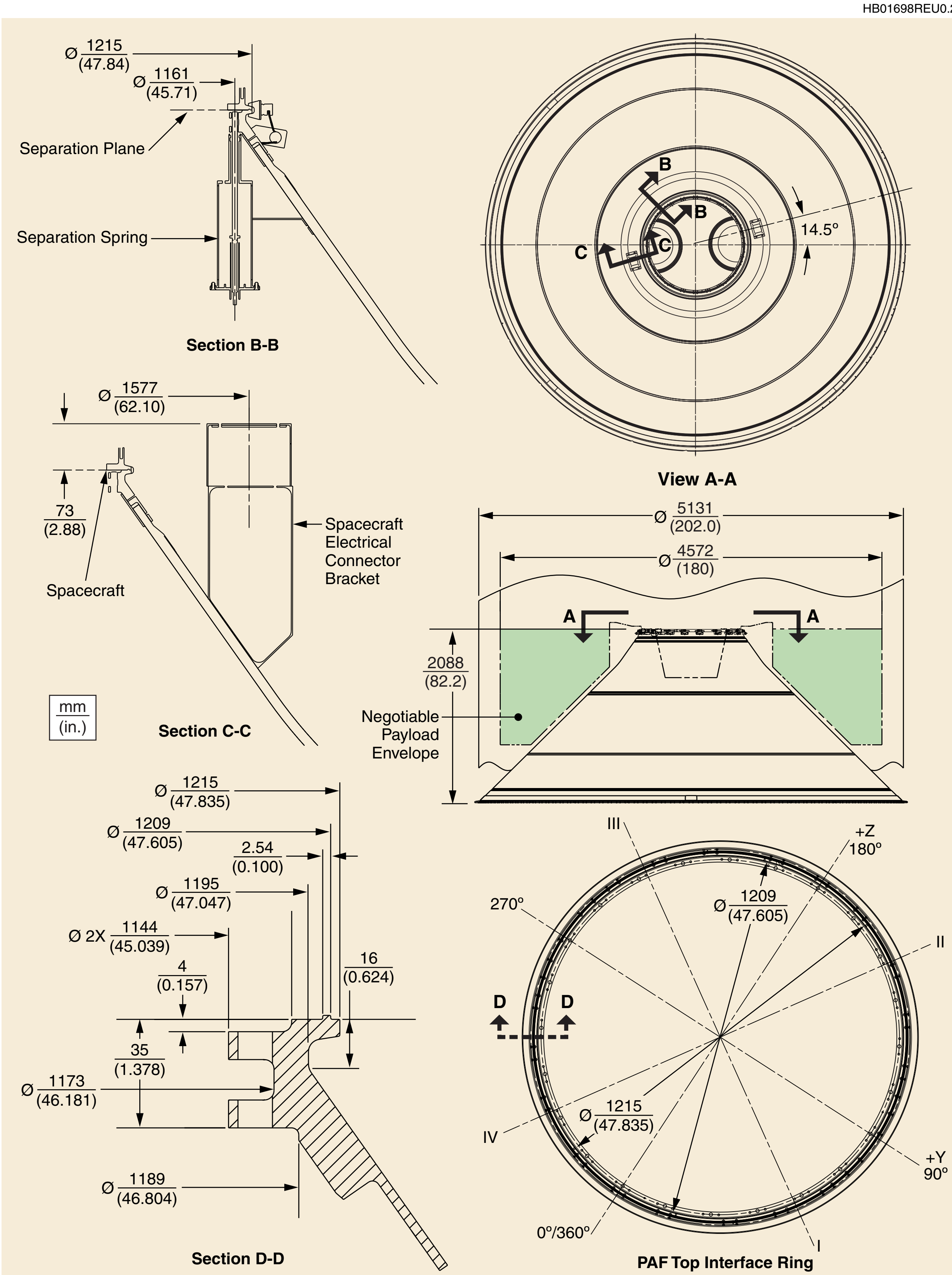


**Figure 5-7. Delta IV 1194-5 PAF**

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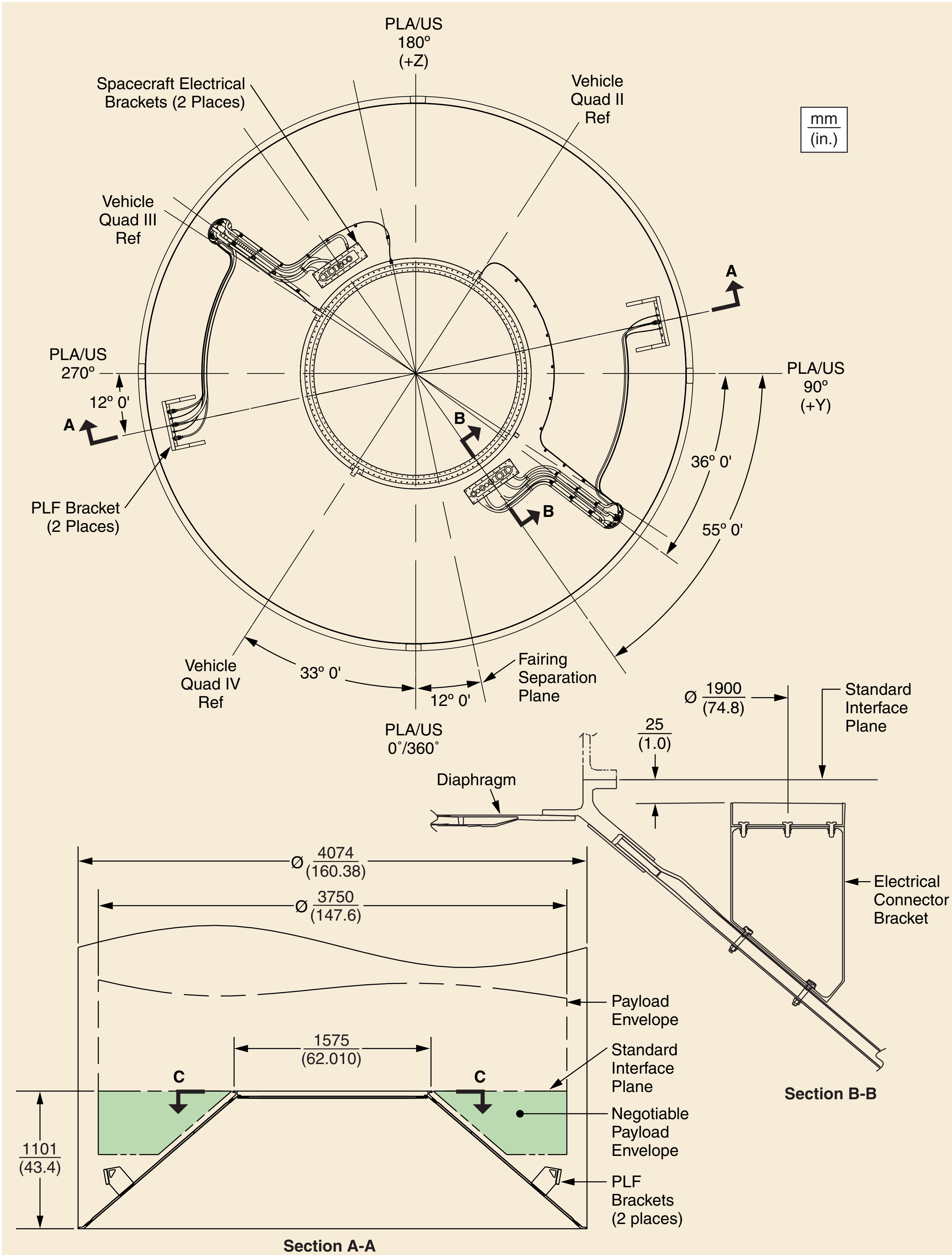


**Figure 5-8. Delta IV EELV 1575-4 PAF**

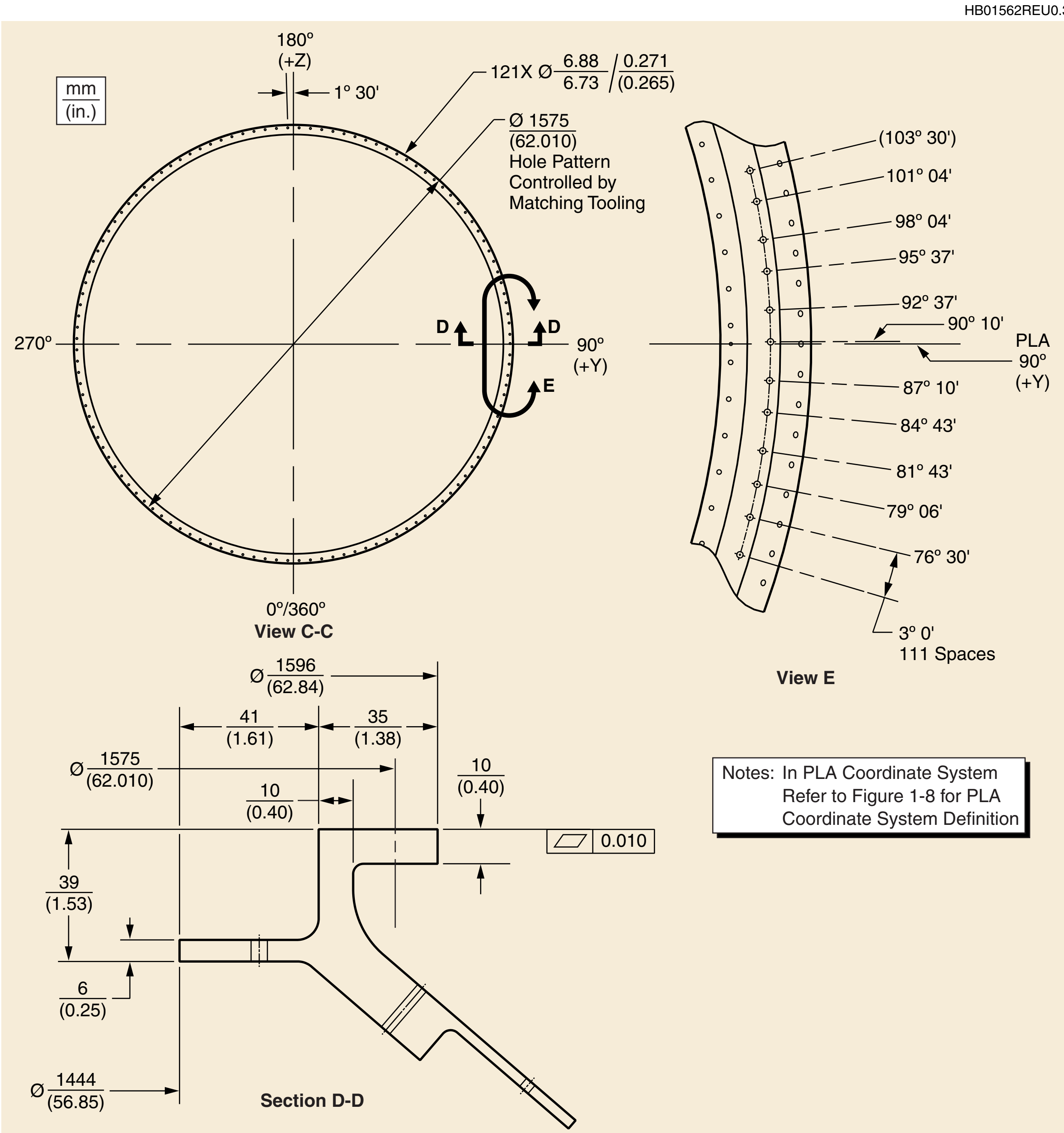


**Figure 5-9. Delta IV EELV 1575-4 PAF**

to a conic shell design used on other Delta IV PAFs). This truss structure offers a higher stiffness-to-weight ratio for the larger interface diameter.

### 5.2.7 Payload Mass vs. Center-of-Gravity Location Capabilities

Figures 5-17 and 5-18 provide the estimated capabilities for certain 4-m and 5-m PAFs. The capabilities are plotted in terms of payload mass and center-of-gravity (CG) location above the payload separation plane and are based on extrapolation of analytical results for generic payloads.

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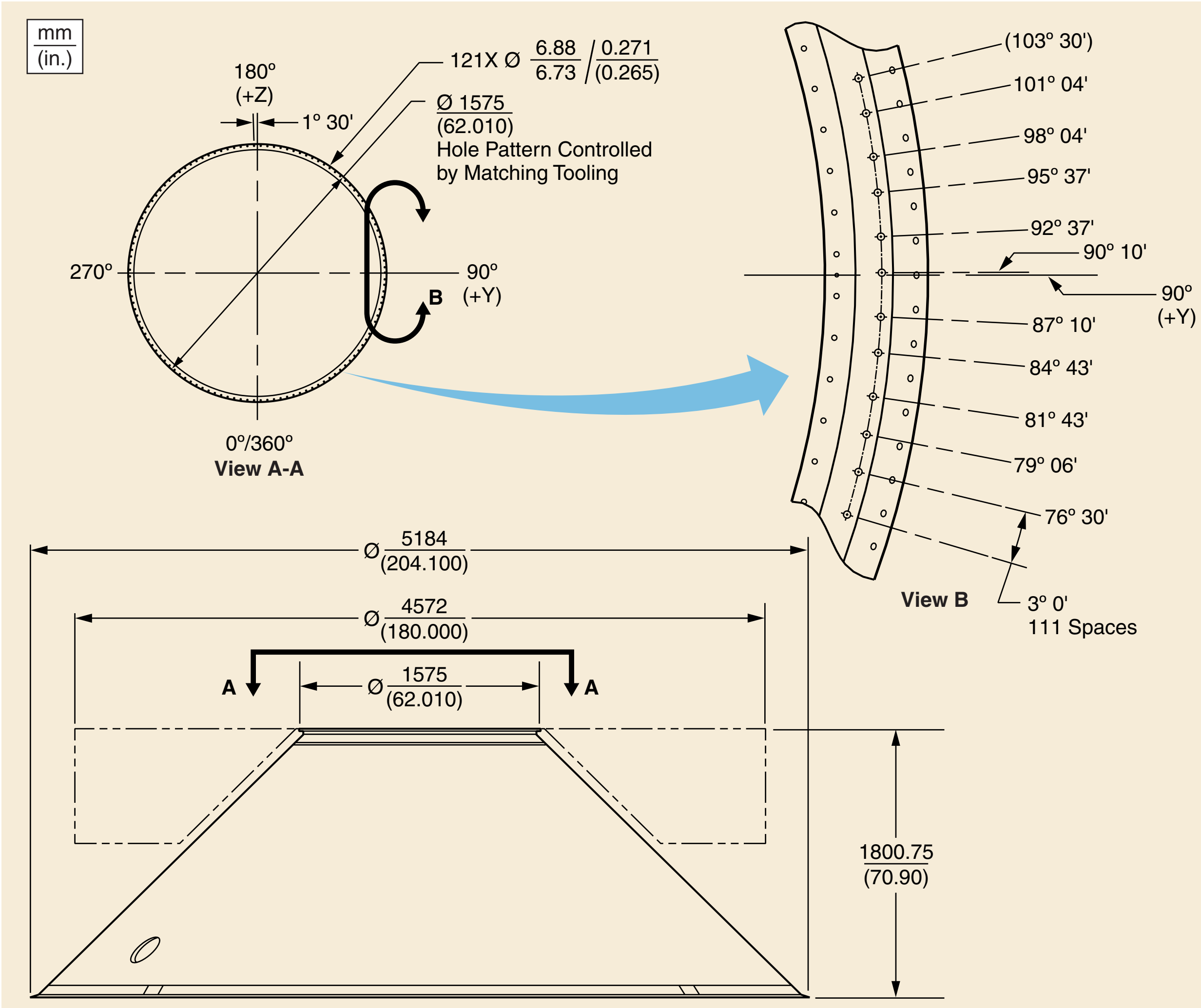


**Figure 5-10. Delta IV EELV 1575-4 PAF**

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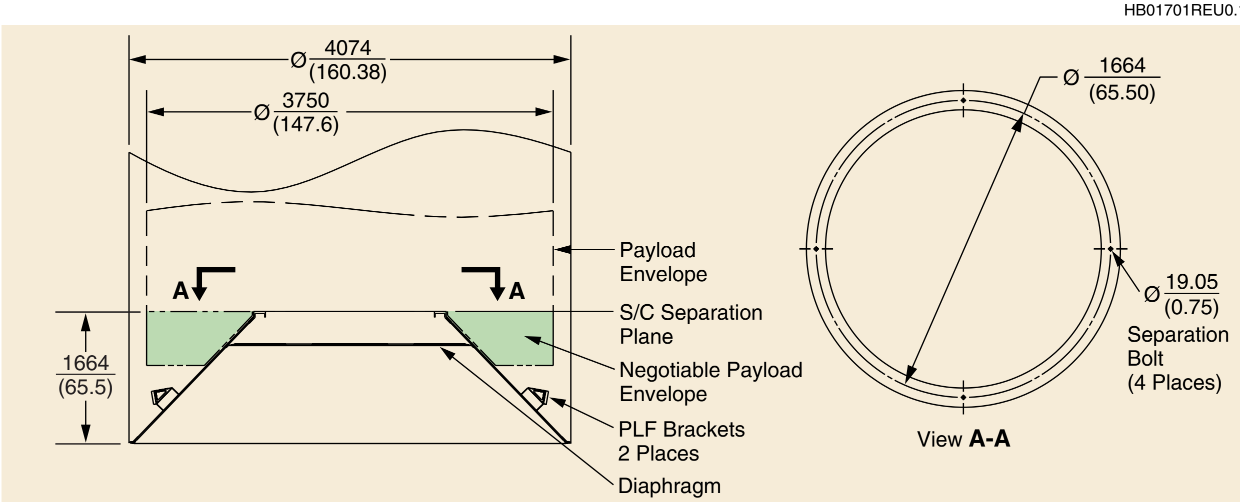


**Figure 5-11. Delta IV 1664-4 PAF**

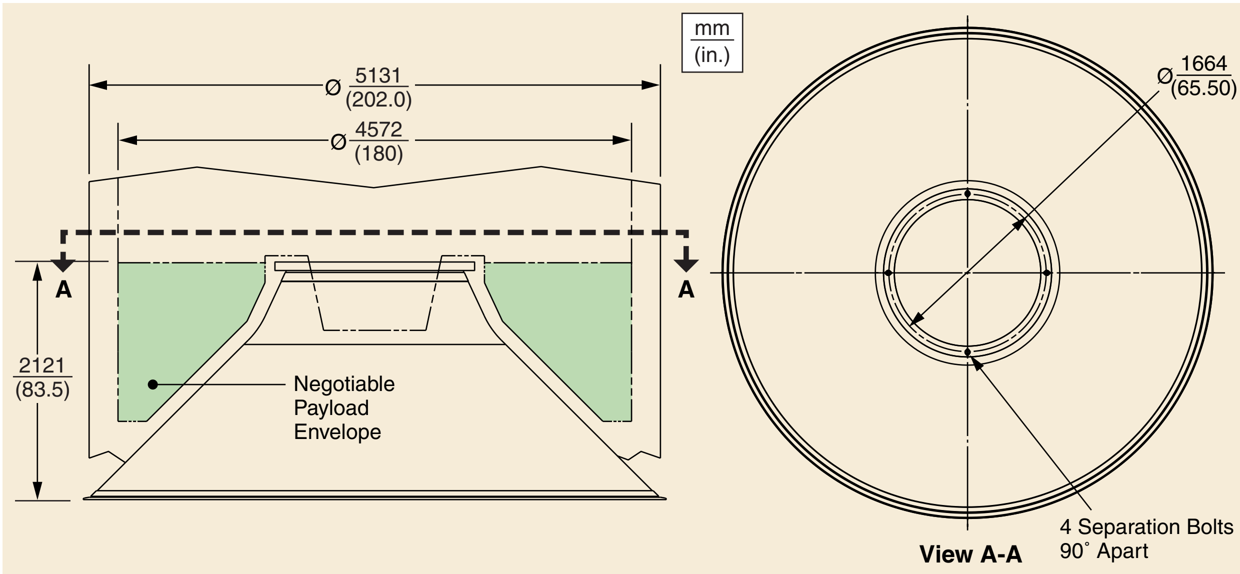


**Figure 5-12. Delta IV 1664-5 PAF**

Therefore, when the payload configuration is determined, Boeing will perform a coupled-loads analysis to verify that the structural capabilities of both the payload and launch vehicle are not exceeded. Capability of other PAFs will be distributed once available; please contact Delta Launch Services for information.

### 5.2.8 Other Payload Attach Fittings

Customers with a unique interface incompatible with the Delta IV 4-m or 5-m PAFs discussed in this section should contact Delta Launch Services for more options. Other requirements may also be accommodated through coordination with Delta Launch Services.

## 5.3 DELTA IV ELECTRICAL INTERFACES

The standard electrical interfaces with the payload are identical for all Delta IV configurations and for either launch site. The interface is defined at the standard electric interface panel (SEIP) on the PAF. At that location, electrical cables from the launch vehicle mate with cables from the payload until time of payload separation. For multiple spacecraft with special dispenser systems, or other special configurations, this interface may be mechanized differently. Similarly, some payloads may require additional capacity and/or special electrical functions not provided by the standard interface. The Delta team will work closely with its customers to define the necessary enhancements to meet their needs

The Delta IV avionics system, with two independent power systems, system data buses, and interface electronics, provides full redundancy to the payload interface and is designed to sustain a single-point failure without degradation of avionics performance.

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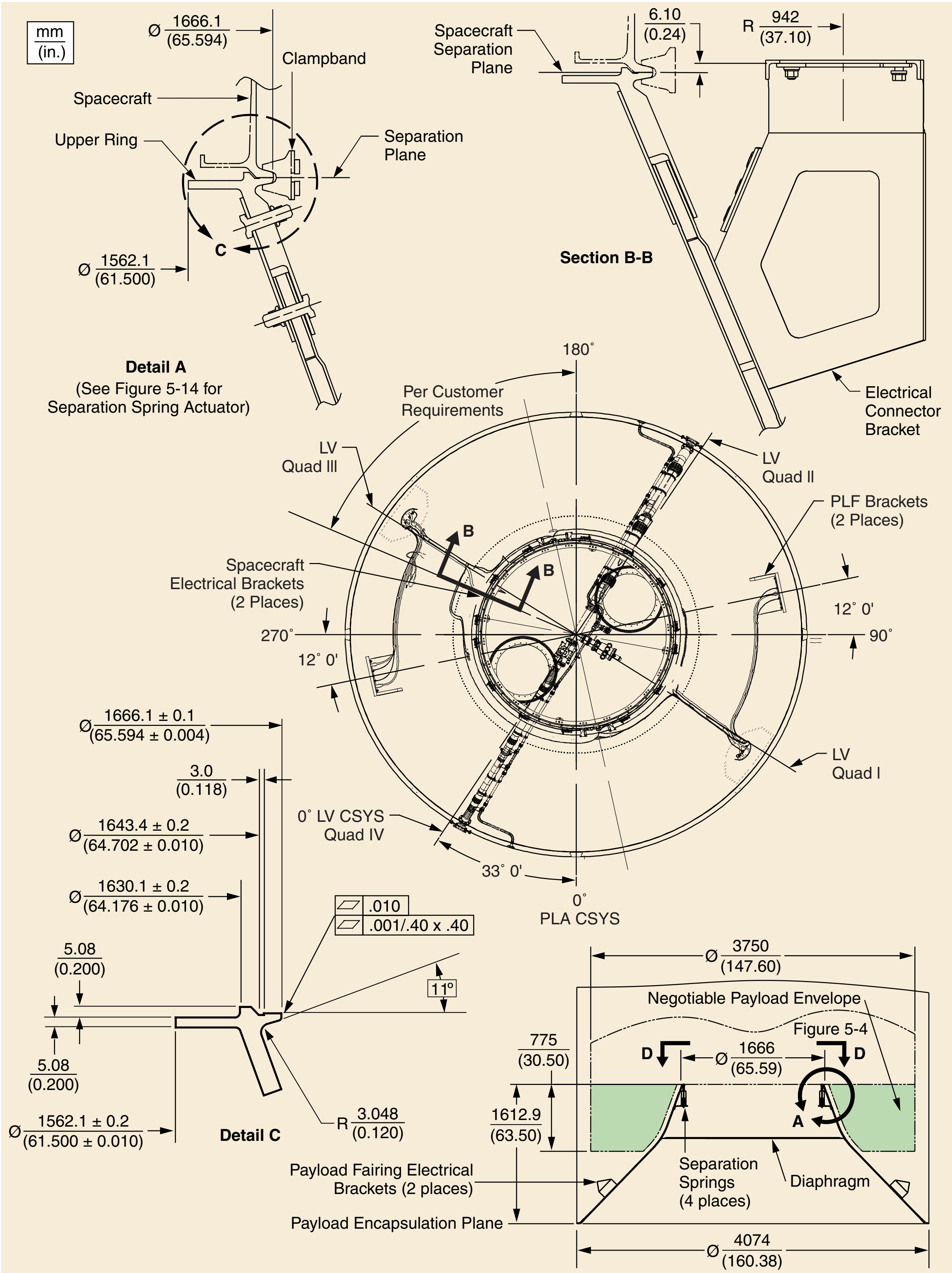


**Figure 5-13. Delta IV 1666-4 PAF**

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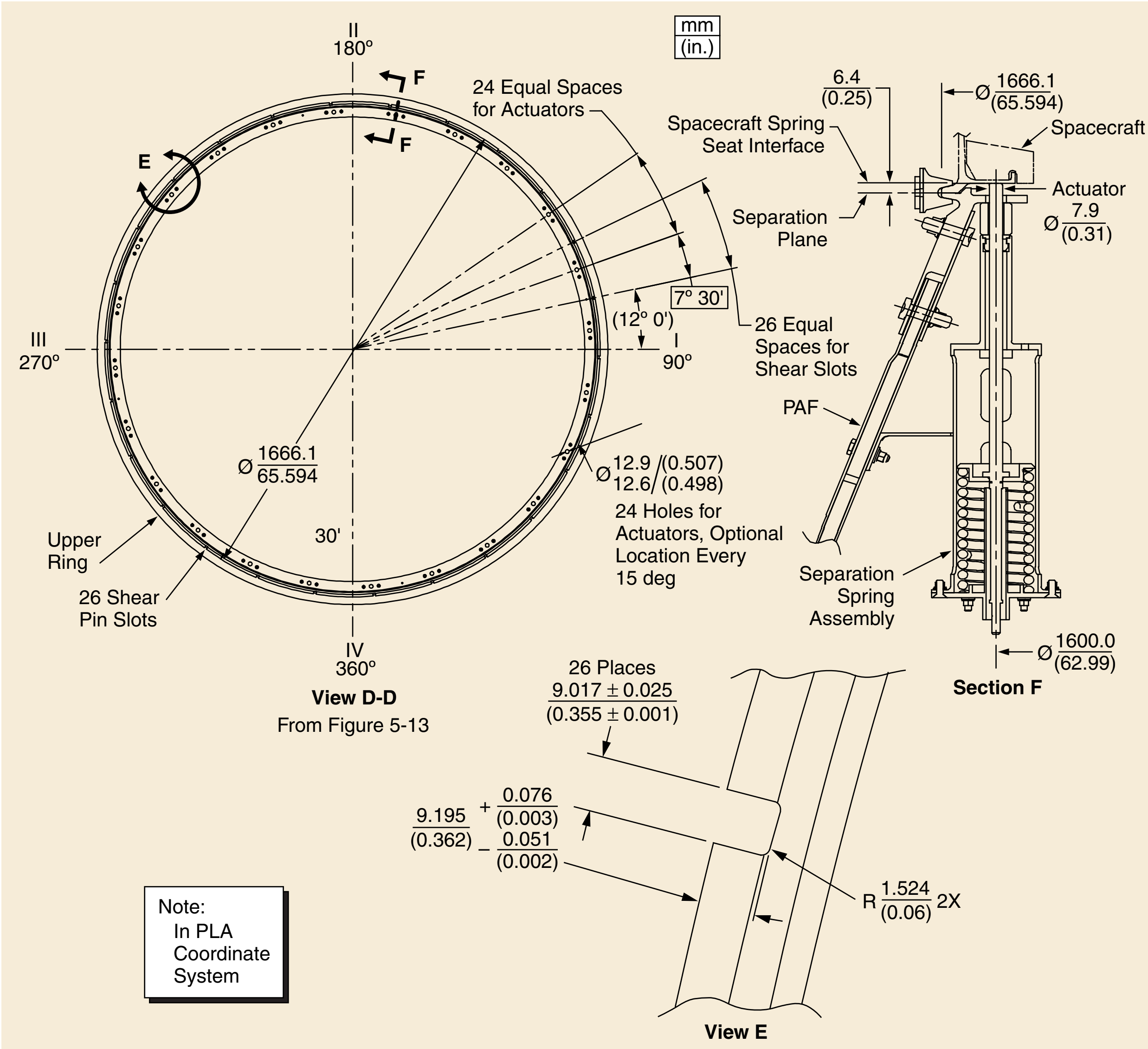


**Figure 5-14. 1666-4 PAF Separation Spring Assembly and Shear Slot Detail**

This standard interface supports several different electrical functions and can be separated into two categories, ground-to-payload functions and launch-vehicle-to-payload functions, as summarized in Table 5-1.

This guide does not identify all electrical interface requirements. Customers should contact Delta Launch Services for additional interface requirements.

### 5.3.1 Ground-to-Payload Functions

The standard electrical interface provides for the direct interconnection of payload power, command, and monitoring signals to a specially provided space vehicle interface panel (SVIP) in an electrical ground support equipment (EGSE) room provided by Boeing for the payload customer. In this room, the payload customer can install any special equipment needed to monitor and

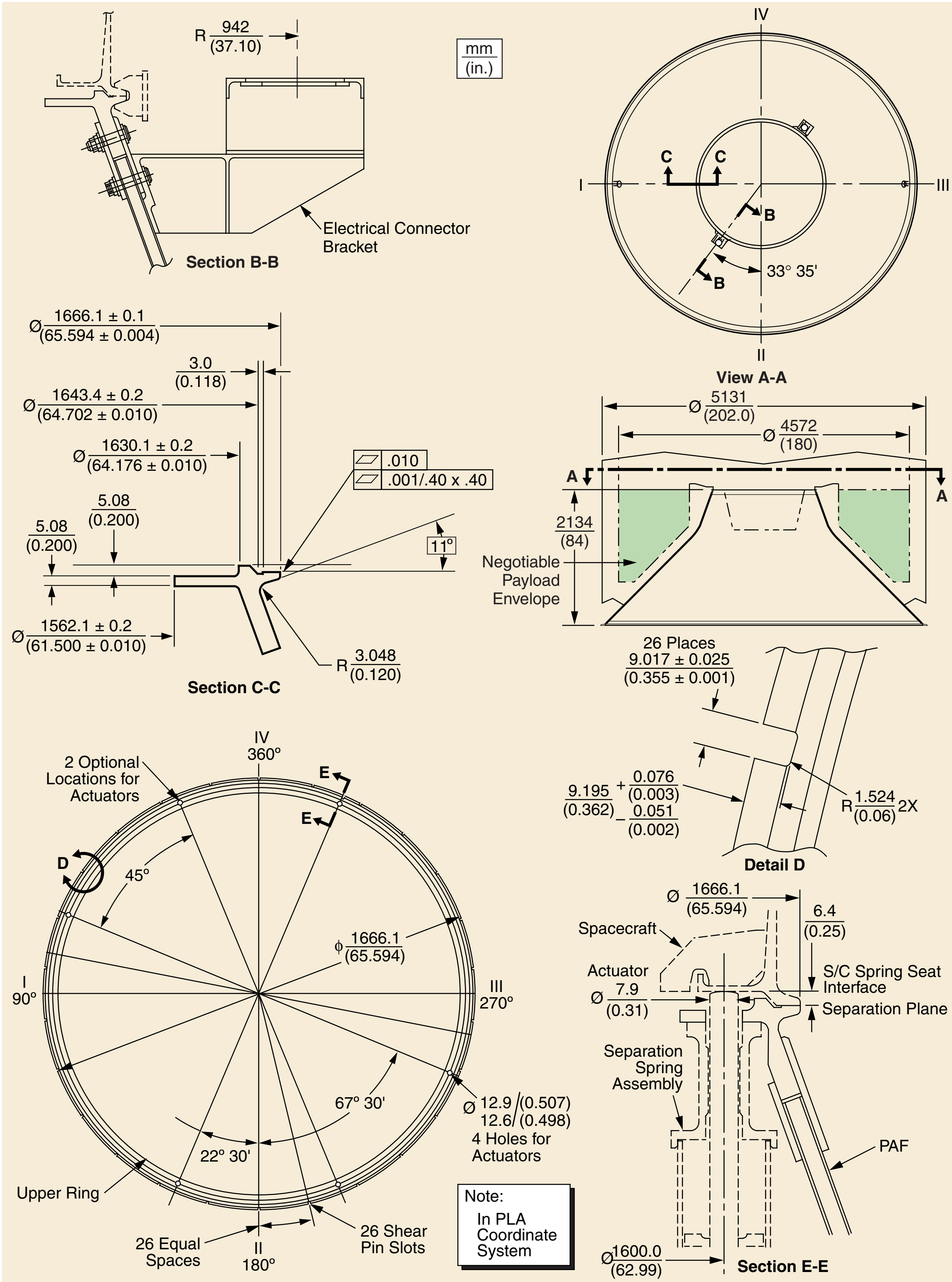


**Figure 5-15. Delta IV 1666-5 PAF**

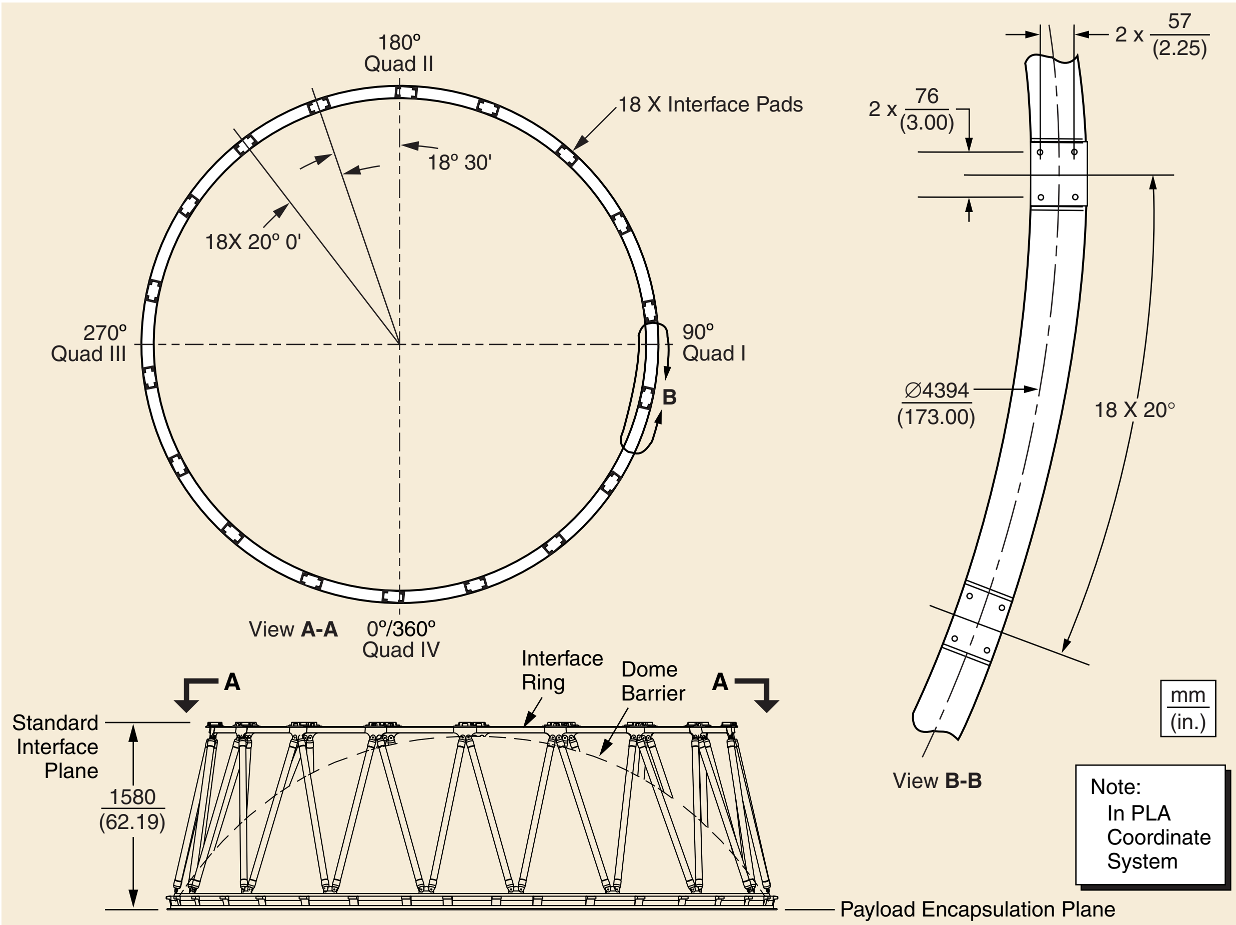


**Figure 5-16. Delta IV EELV 4394-5 PAF**

maintain the payload while it is on the launch pad. This interface is available from the time of mating the encapsulated payload to the launch vehicle until launch.

The feed-through cabling goes from the SEIP, through the second stage of the launch vehicle, out one of the vehicle's electrical umbilical connectors, over and down the fixed umbilical tower (FUT), and finally to the EGSE room. Twelve twisted pairs of power lines can be used to provide external power to the payload and charge its batteries, or other high-current applications, up to 11 A per pair (at 126 VDC maximum). Another 60 twisted pairs of data/control/monitoring lines support up to 3 A per pair (at 126 VDC maximum) for such functions as voltage, current and temperature monitoring, battery-voltage sensing, initiating, and monitoring self-test.

Three-phase, uninterruptible facility power is available to the customer in the ESGE room as follows:

Voltage: 120/208 VAC + 5%

Frequency: 60 Hz + 1%

Total harmonic distortion (THD): Less than 5%

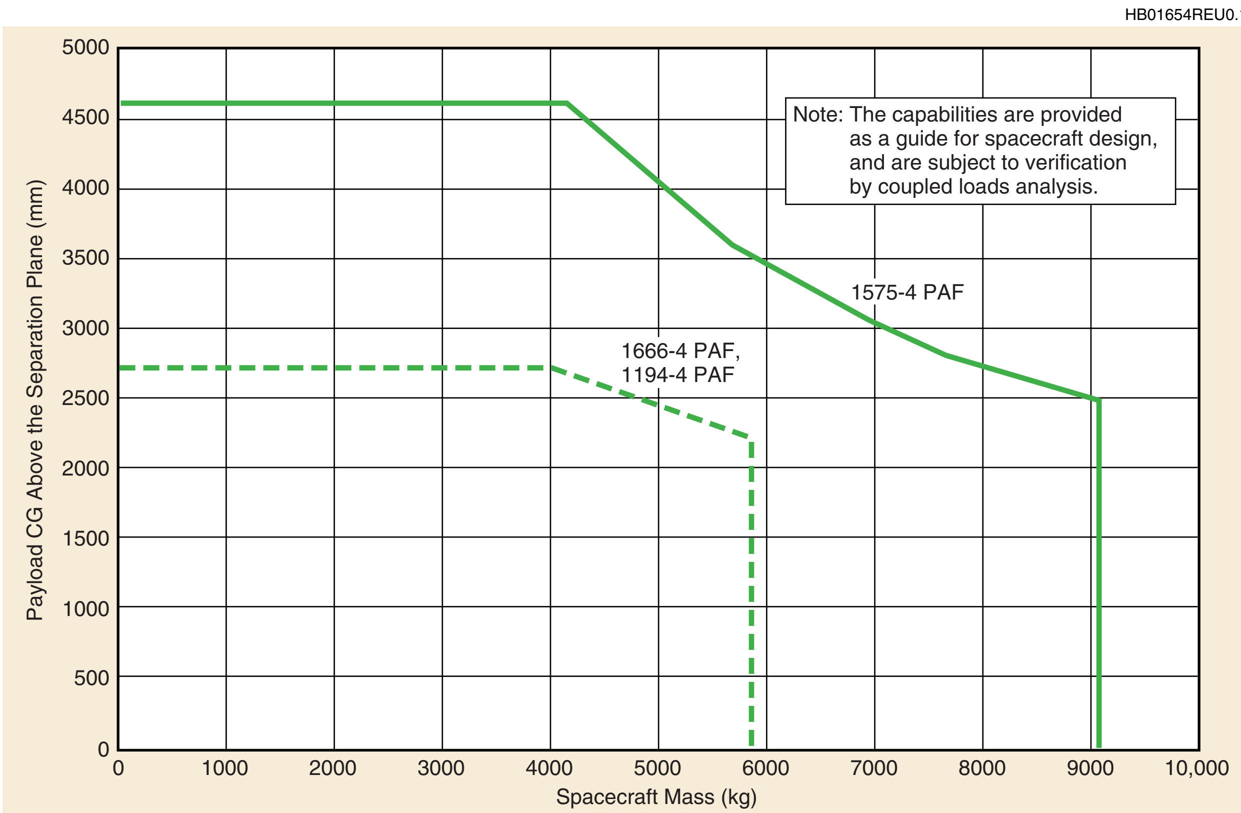


**Figure 5-17. 4-m PAF Spacecraft Center of Gravity vs. Mass Capability**

| | |
|---|---|
| Voltage transients: | Less than 200% of nominal rms voltage for not more than 200 μsec |
| Maximum load current: | 20 kVA |

Note: 50-Hz power can be provided through coordination with Delta Launch Services.

### 5.3.2 Launch-Vehicle-to-Payload Functions

The standard electrical interface provides for four launch-vehicle-to-payload functions while in flight as described in the following sections.

**5.3.2.1 Ordnance Discretes.** The standard electrical interface provides for eight primary and eight redundant ordnance circuits to ignite up to eight pairs of electro-explosive devices (EEDs) provided by the payload (or dispenser system).

Each circuit provides (one time only) a minimum of 5 A into a 0.9- to 2.0-Ω load (wiring and one EED) with a duration of 40 ± 10 msec and is current-limited to 18 A. Each pair of circuits (the primary and the redundant) will be turned ON either within 5 msec of each other or within 80 ± 10 msec, depending on customer requirements. Any number of the eight pairs of ordnance circuits may be commanded ON at the same time.

When commanded ON, each circuit appears as a 28-VDC (nominal) current source across the two-wire interface (High and Return), and as a direct short (for safety purposes) when not commanded ON.

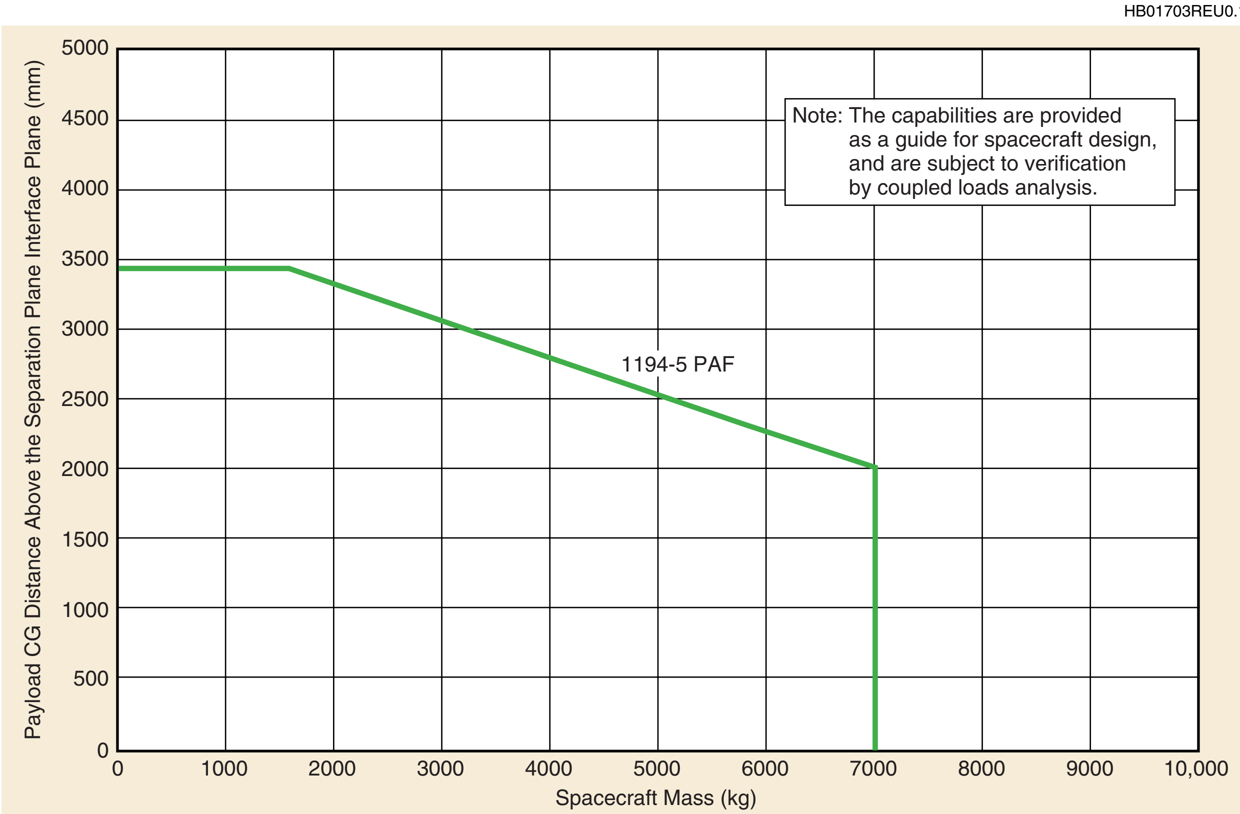


**Figure 5-18. 5-m PAF Spacecraft Center of Gravity vs. Mass Capability**

**Table 5-1. Electrical Interface Signal Functions**

| Signal function | Signal quantity | Wire count | Max current | Max voltage |
|---|---|---|---|---|
| **Ground-to-payload functions** | | | | |
| Ground power | 12 pairs | 24 | 11 A | 126 VDC |
| Data/command/monitoring | 60 pairs | 120 | 3 A | 126 VDC |
| **Launch-vehicle-to-payload functions** | | | | |
| Ordnance discretes | 8 redundant pairs | 32 | 18 A | 36 VDC |
| 28 VDC command discretes or switch closures | 8 redundant pairs | 32 | 500 mA<br>100 mA | 33 VDC<br>32 VDC |
| Breakwire separation monitors | 1 redundant pair | 4 | -- | -- |
| Telemetry channels (data and clock) | 2 | 8 | -- | -- |

**5.3.2.2 28-VDC Command Discretes or Switch Closures.** The standard electrical interface provides for eight primary and eight redundant circuits that can be configured as either 28-VDC command discretes or switch closures, depending on customer needs. (All circuits must be configured in the same way.)

If the circuits are configured as 28-VDC command discretes, the two-wire (High and Return) avionics circuits will provide the payload with up to 500 mA with a voltage of 23 to 33 VDC when commanded ON. When configured as switch closures, the two-wire (In and Out) avionics circuits will act as a solid-state relay and support the passage of up to 1 A at a voltage of 22 to 32 VDC when commanded ON. (When OFF, the leakage current shall be less than 1 mA.)

In either case, the circuits can be commanded in any sequence with up to ten changes in state (ON/OFF) for each circuit, but each commanded duration must be between 20 msec and 10 sec. Hence, each circuit may not be ON for a cumulative time of greater than 50 sec.

**5.3.2.3 Breakwire Separation Monitors.** The standard electrical interface provides for one pair of redundant separation monitor circuits. Typically, the payload provides a shorting jumper on its side of the circuit, and the avionics detects an open circuit when separation occurs. The jumper (and any wiring) in the payload must present less than 1 Ω before separation, and the circuit must open or be greater than 1 MΩ after separation.

If there is more than one payload and monitoring of each is required, the customer should request that additional pairs of monitors be provided.

**5.3.2.4 Telemetry Channels.** The standard electrical interface provides for two telemetry channels, each capable of receiving up to 4 kBps of data, and each transmitting to the master telemetry unit (MTU) in the upper stage.

Each avionics channel consists of two RS-422 differential line receivers, one for data (non-return-to-zero—phase L) and one for the clock. Data is sampled on the FALSE-to-TRUE transition of the clock.

### 5.3.3 Spacecraft Connectors. TBD

### 5.3.4 Customer Wiring Documentation

To ensure proper attention to the customer’s needs, information regarding customer wiring documentation shall be furnished by the customer.

# Section 6
# LAUNCH OPERATIONS AT EASTERN RANGE

This section presents a description of Delta launch vehicle operations associated with Space Launch Complex 37 (SLC-37) at Cape Canaveral Air Force Station (CCAFS), Florida. Delta IV prelaunch processing and spacecraft operations conducted prior to launch are described.

## 6.1 ORGANIZATIONS

The Boeing Company operates the Delta launch system and maintains a team that provides launch services to the USAF, NASA, and commercial customers at CCAFS. Boeing provides the interface to the Federal Aviation Administration (FAA) and the Department of Transportation (DOT) for the licensing and certification needed to launch commercial payloads using Delta IV.

Boeing has an established interface with the USAF 45th Space Wing (SW) Directorate of Plans. The USAF designates a program support manager (PSM) to be a representative of the 45th Space Wing. The PSM serves as the official interface for all USAF support and services requested. These services include range instrumentation, facilities/equipment operation and maintenance, and safety, security, and logistics support. Requirements for range services are described in documents prepared and submitted to the government by Boeing, based on inputs from the spacecraft contractor and using the government's universal documentation system (UDS) format (see Section 8, Payload Integration). The organizations that support a launch are shown in Figure 6-1. For each mission, a spacecraft coordinator from the Boeing CCAFS launch team is assigned to assist the spacecraft team during the launch campaign by helping to obtain safety approval of the payload test procedures and operations, integrating the spacecraft operations into the launch vehicle activities, and serving as the interface between the payload customer and test conductor in the launch control center (LCC) during the countdown and launch. Boeing interfaces with NASA at Kennedy Space Center (KSC) through the Expendable Launch Vehicle and Payload Carriers Program Office. NASA designates a launch service integration manager who arranges for all of the support requested from NASA for a launch from CCAFS.

Boeing also has an established working relationship with Astrotech Space Operations (ASO). Astrotech owns and operates a processing facility for commercial payloads in Titusville, Florida, in support of Delta missions. Use of these facilities and services may be arranged for the customer by Boeing.

## 6.2 FACILITIES

In addition to the facilities required for Delta IV launch vehicles, the specialized payload processing facilities (PPFs) listed below are provided for checkout and preparation of government

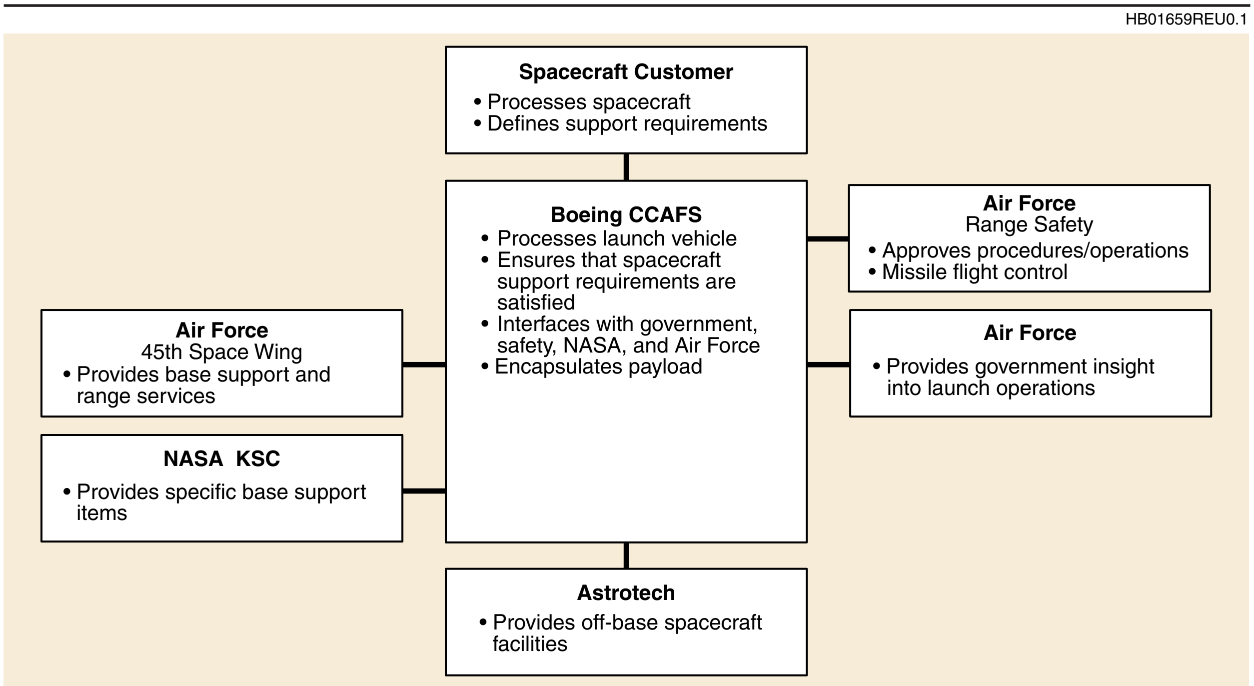


**Figure 6-1. Organizational Interfaces for Commercial Users**

and commercial spacecraft. Laboratories, cleanrooms, receiving and shipping areas, hazardous operations areas, and offices are provided for use by payload project personnel.

Offline encapsulation of fueled payloads is a key element of the Delta IV program. Boeing conducted a study to define existing USAF, NASA, and commercial facilities where this could be accomplished without facility modification. Details of this study are presented in Section 6.2.1. The Boeing study at the Eastern Range revealed the following:

### USAF Facilities

- Defense Satellite Communication System (DSCS) processing facility (DPF).
- Shuttle payload integration facility (SPIF).

Hazardous processing may be accomplished at these facilities as well. Department of Defense (DOD) payloads will be processed through the SPIF.

### NASA Facilities

- Vertical processing facility (VPF).
- Spacecraft assembly and encapsulation facility (SAEF-2).
- Multi-payload processing facility (MPPF).
- Payload hazardous processing facility (PHPF).

### Commercial Facilities

- Astrotech Space Operations (ASO).

In the following paragraphs, detailed information is presented on ASO facilities. Users guides for the other PPFs listed can be provided upon request.

Commercial spacecraft will normally be processed through the Astrotech facilities. Payload processing facilities controlled by NASA and the USAF will be used for commercial launches only under special circumstances.

The spacecraft contractor must provide its own test equipment for spacecraft preparations, including telemetry receivers and command and control ground stations. Communications equipment, including antennas, is available as base equipment for voice and data transmissions.

Transportation and handling of the spacecraft and associated equipment from any of the local airports to the spacecraft processing facility are provided by the spacecraft contractor-selected processing facility with assistance from Boeing. Equipment and personnel are also available for loading and unloading operations. Shipping containers and handling fixtures attached to the spacecraft are provided by the spacecraft contractor.

Shipping and handling of hazardous materials such as electro-explosive devices (EEDs) and radioactive sources must be in accordance with applicable regulations. It is the responsibility of the spacecraft contractor to identify these items and become familiar with such regulations. Included are regulations imposed by NASA, USAF, and FAA (refer to Section 9).

### 6.2.1 Astrotech Space Operations Facilities

The Astrotech facility is located approximately 5.6 km (3 mi) west of the Gate 3 entrance to KSC near the intersection of State Road 405 and State Road 407 in the Spaceport Industrial Park in Titusville, Florida (Figures 6-2 and 6-3). This facility includes 7,400 $m^2$ (80,000 $ft^2$) of industrial space constructed on 15.2 hectares (37.5 acres) of land.

There are nine major buildings on the site, as shown in Figure 6-4. A general description of each building is given below. For additional details, a copy of the Astrotech Facility Accommodation Handbook is available.

Building 1/1A, the nonhazardous payload processing facility (PPF), is used for payload final assembly and checkout. It houses payload cleanroom high bays, control rooms, and offices.

Building 2, the hazardous processing facility (HPF), houses three explosion-proof high bays for hazardous operations including liquid propellant and solid rocket motor handling, and spin balancing, and two bays for payload attach fitting (PAF)/payload fairing preparations, and payload encapsulation.

Building 3, the environmental storage facility, provides six secure, air-conditioned, masonry-constructed bays for storage of high-value hardware or hazardous materials.

Building 4, the warehouse storage facility, provides covered storage space for shipping containers, hoisting and handling equipment, and other articles not requiring environmental control.

Building 5, the owner/operator office area, is an executive office building that provides spacecraft project officials with office space for conducting business during their stay at Astrotech and the Eastern Range.

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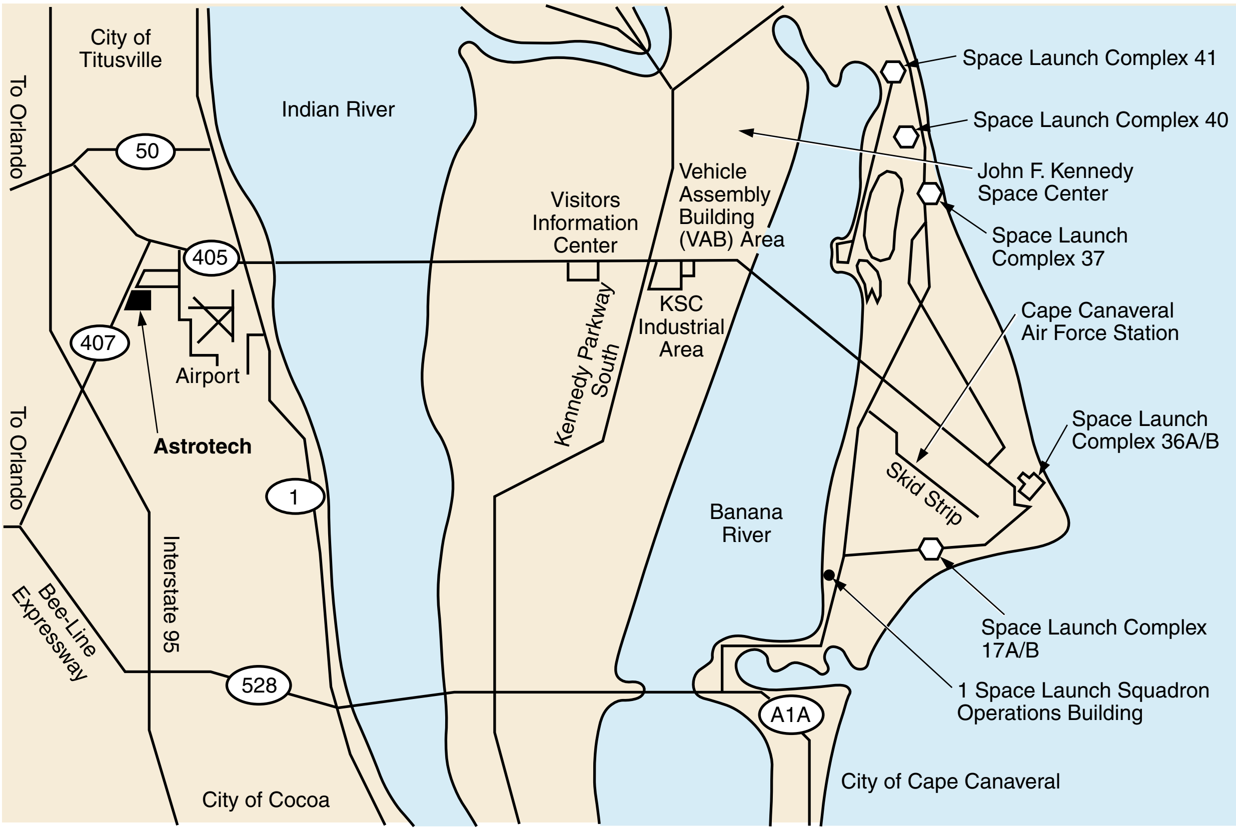


**Figure 6-2. Astrotech Site Location**

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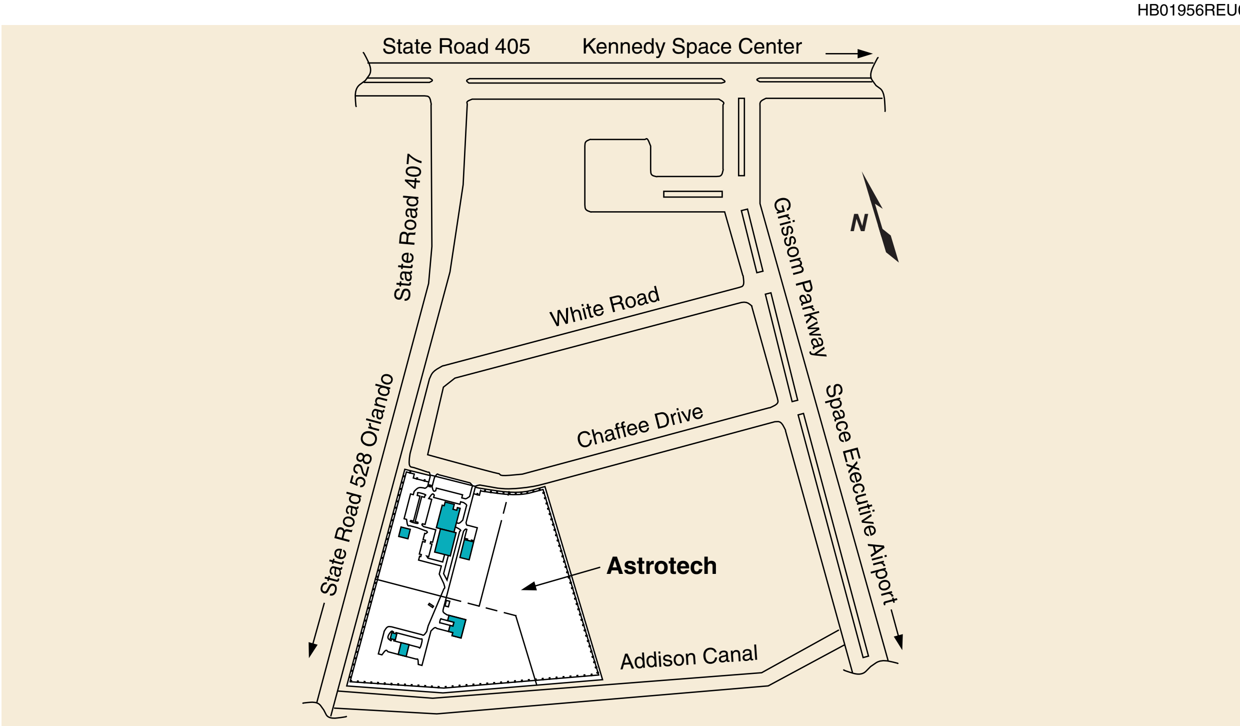


**Figure 6-3. Astrotech Complex Location**

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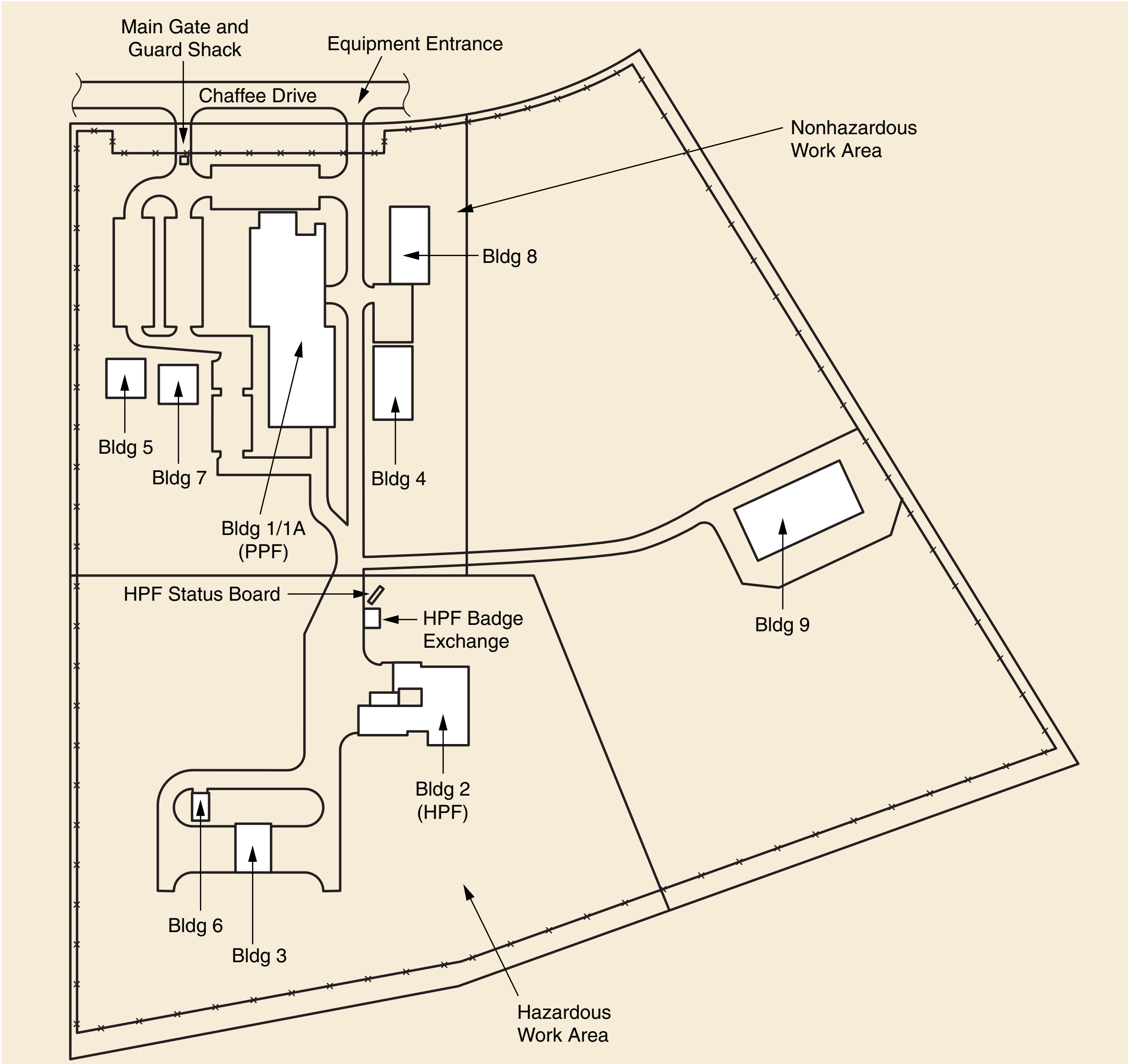


**Figure 6-4. Astrotech Building Locations**

Building 6, the fairing support facility, provides covered storage space for launch vehicle hardware and equipment, and other articles not requiring environmental control.

Building 7, the Boeing office area, provides Delta IV personnel with office space during the term of contract.

Building 8 is the launch operations storage building.

Building 9, the Delta IV payload processing facility, is a dedicated satellite preparation and encapsulation facility being built by ASO to support Delta IV satellite customers.

**6.2.1.1 Astrotech Building 1/1A (PPF).** Building 1/1A has overall plan dimensions of approximately 113 m by 34 m (370 ft by 110 ft) and a maximum height of approximately 18 m

(60 ft). Major features are two airlocks, four high bays with control rooms, and an office complex. The airlocks and high bays are class 100,000 cleanrooms, with the ability to achieve class 10,000 or better cleanliness levels using strict operational controls. The floor coverings are made of an electrostatic-dissipating (high-impedance) epoxy-based material. The ground-level floor plan of building 1/1A is shown in Figure 6-5, and the upper-level floor plan is shown in Figure 6-6.

**6.2.1.1.1 Building 1 (PPF).** The airlock in building 1 has a floor area measuring 9.1 m by 36.6 m (30 ft by 120 ft) and a clear vertical ceiling height of 7.0 m (23 ft). It provides

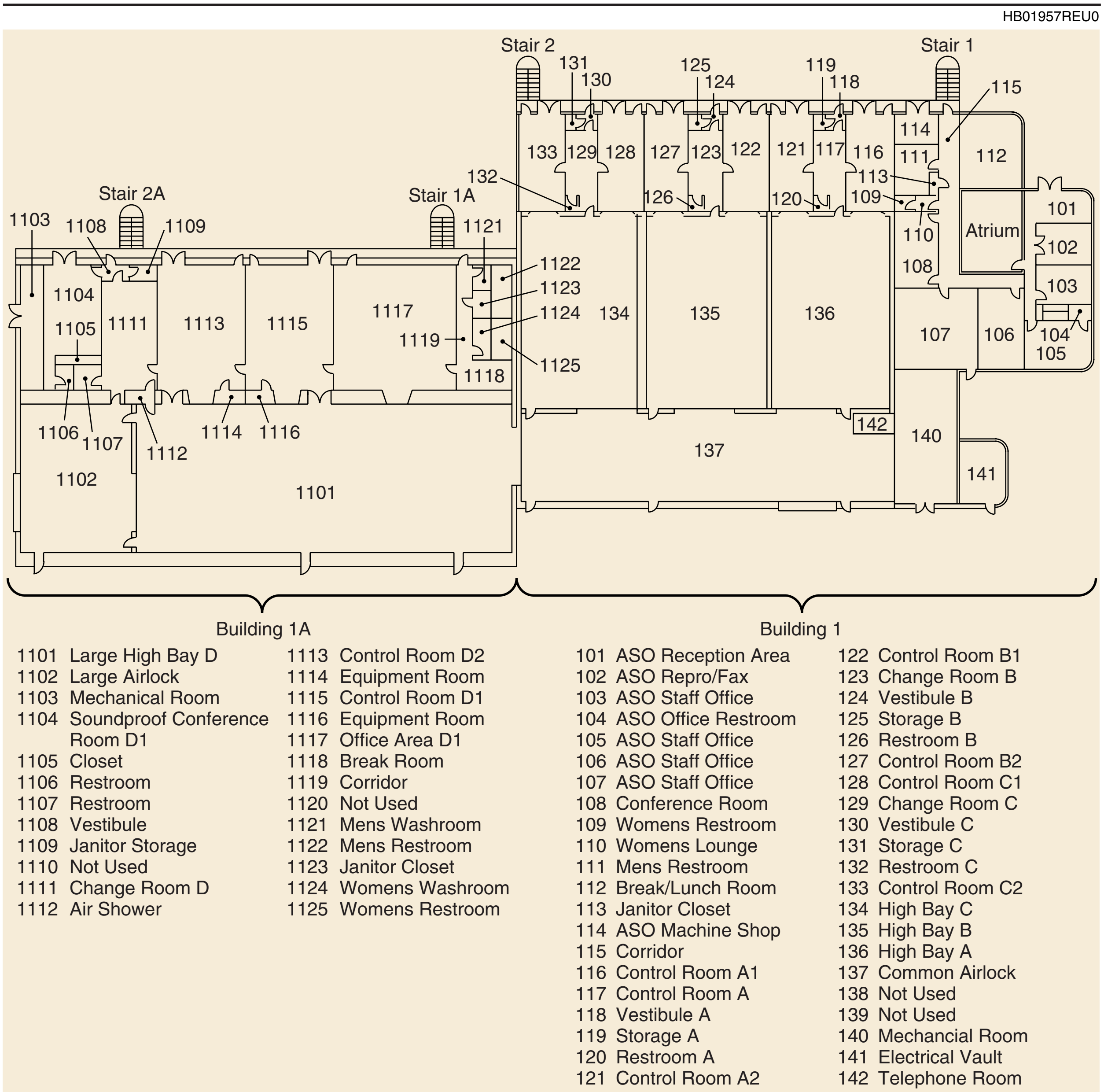


**Figure 6-5. First-Level Floor Plan, Building 1/1A (PPF), Astrotech**

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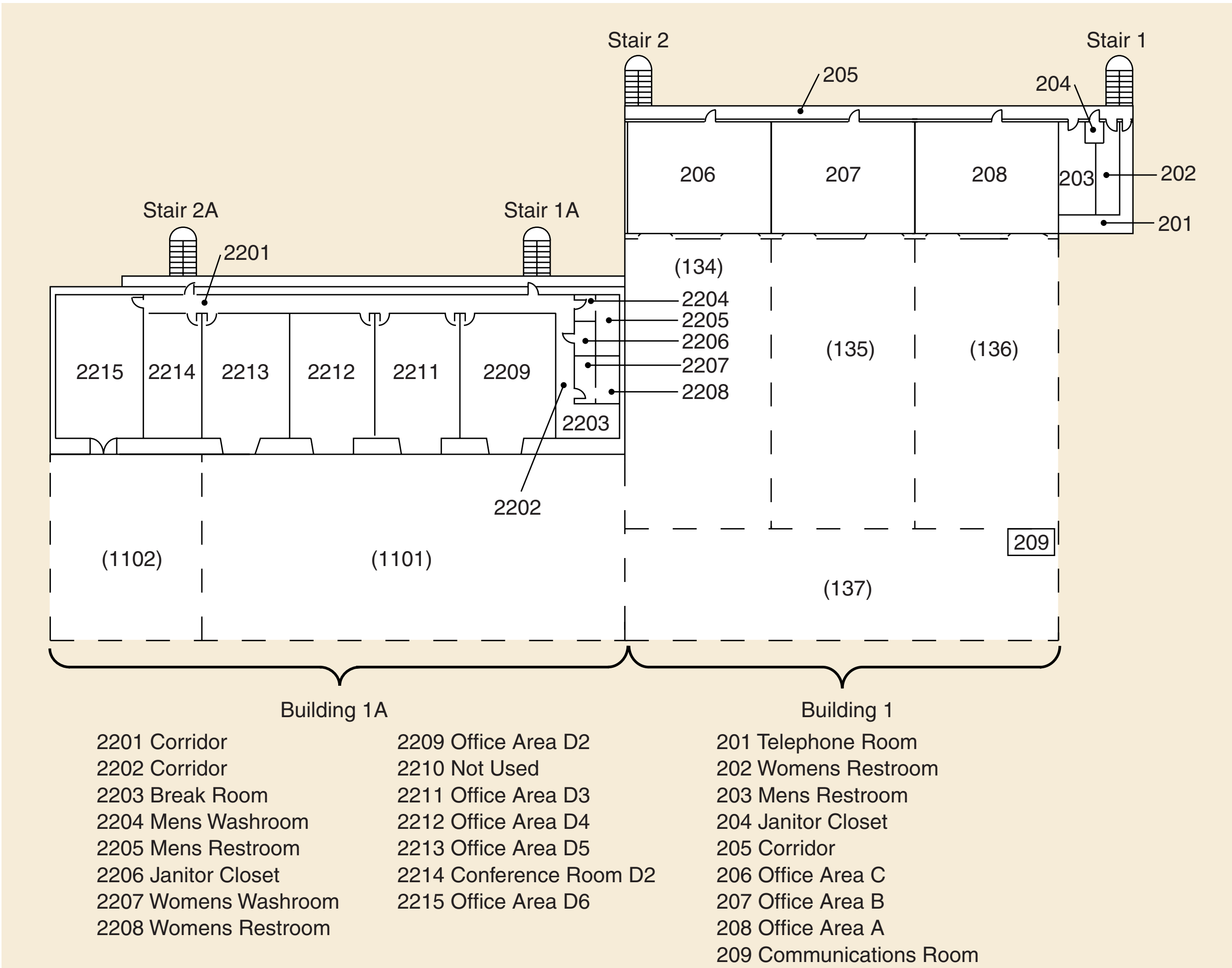


**Figure 6-6. Second-Level Floor Plan, Building 1/1A (PPF), Astrotech**

environmentally controlled external access to the three high bays, and interconnects with building 1A. There is no overhead crane in the airlock. Three radio frequency (RF) antenna towers are located on the roof of the airlock. Each of the three high bays in building 1 has a floor area measuring 12.2 m by 18.3 m (40 ft by 60 ft) and a clear vertical ceiling height of 13.2 m (43.5 ft). Each high bay has a 9072-kg (10-ton) overhead traveling bridge crane with a maximum hook height of 11.3 m (37 ft).

There are two adjacent control rooms for each high bay. Each control room has a floor area measuring 4.3 m by 9.1 m (14 ft by 30 ft) with a 2.7-m (8.9-ft) ceiling height. A large exterior door is provided in each control room to facilitate installation and removal of equipment. Each control room has a large window for viewing activities in the high bay.

Garment rooms (change rooms) provide personnel access and support to the high-bay areas. Limiting access to the high bays through these rooms helps control personnel traffic and maintains a cleanroom environment.

Office accommodations for spacecraft project personnel are provided on the upper floor of building 1 (Figure 6-6). This space is conveniently located near the spacecraft processing area and contains windows for viewing activities in the high bay.

The remaining areas of building 1 contain the Astrotech offices and shared support areas including break room, supply/photocopy room, restrooms, and a 24-person conference room.

**6.2.1.1.2 Building 1A.** In addition to providing access through the building 1 airlock, building 1A contains a separate airlock that is an extension of the high bay and provides environmentally controlled external access. The airlock has a floor area measuring 12.2 m by 15.5 m (40 ft by 51 ft) and a clear vertical ceiling height of 18.3 m (60 ft). The airlock is a class 100,000 cleanroom. External access for payloads and equipment is provided through a large exterior door.

The exterior wall of the airlock adjacent to the exterior overhead door contains a 4.3-m by 4.3-m (14-ft by 14-ft) RF-transparent window that looks out onto a far-field antenna range that has a 30.5-m (100-ft)-high target tower located approximately 91.4 m (300 ft) downrange. The center of the window is 5.8 m (19 ft) above the floor.

The high bay has a floor area measuring 15.5 m by 38.1 m (51 ft by 125 ft) and a clear vertical ceiling height of 18.3 m (60 ft). The high bay and airlock share a common 27 215-kg (30-ton) overhead traveling bridge crane with a maximum hook height of 15.2 m (50 ft). Personnel normally enter the high bay through the garment change room to maintain cleanroom standards. The high bay is class 100,000.

Adjacent to the high bay are two control rooms. Each has a floor area measuring 9.1 m by 10.7 m (30 ft by 35 ft) with a 2.8-m (9.3-ft) ceiling height. Each control room has a large interior door to permit the direct transfer of equipment between the high bay and the control room, a large exterior door to facilitate installation and removal of equipment, and a large window for viewing activities in the high bay.

A garment room provides access for personnel and supports the high bay. Limiting access to the high bay through this room helps control personnel traffic and maintains a cleanroom environment. Office accommodations for spacecraft project personnel are provided on the ground floor and upper floor of building 1A. This space is conveniently located near the spacecraft processing area and contains windows for viewing activities in the high bay.

The remaining areas of building 1A contain shared support areas, including break rooms, restrooms, and two 24-person conference rooms (one of which is a secured room designed for discussing and handling classified material).

**6.2.1.2 Astrotech Building 2 (HPF).** Building 2 has overall plan dimensions of 36.6 m by 36.6 m (120 ft by 120 ft) and a height of 14.0 m (46 ft). Major features are two airlocks, three high bays, and two control rooms. The airlocks and high bays have floor coverings made of electrostatic-dissipating (high-impedance) epoxy-based material. They are class 100,000 clean-rooms, with the ability to achieve class 10,000 or better cleanliness levels using strict operational controls. The ground-level floor plan of building 2 is shown in Figure 6-7.

The south airlock provides environmentally controlled access to building 2 through the south high bay. The south airlock has a floor area measuring 8.8 m by 11.6 m (29 ft by 38 ft) and a clear vertical ceiling height of 13.1 m (43 ft). There is no overhead crane in the south airlock.

The north airlock provides environmentally controlled access to building 2 through the north high bay and, if external building 2 access is restricted to the south airlock, it can be used as a fourth high bay. The north airlock has a floor area measuring 12.2 m by 15.2 m (40 ft by 50 ft) and a clear vertical ceiling height of 19.8 m (65 ft). The north airlock has a 27 215-kg (30-ton) overhead traveling bridge crane with a maximum hook height of 16.8 m (55 ft).

The north and south high bays are designed to support payload solid-propellant motor assembly and liquid monopropellant and bipropellant transfer operations. All liquid-propellant transfer operations take place within a 7.6 m by 7.6 m (25 ft by 25 ft) floor area surrounded by a trench system. It is sloped so that any major spill of hazardous propellants drains into the emergency spill retention system. The north airlock is also configured for propellant loading. The center high bay (spin bay) contains an 8391-kg- (18,500-lb)-capacity dynamic balance machine (Schenk-Trebble model E7S spin table) that is designed to balance solid rocket motor upper stages and payload. Because the spin balance table equipment is below the floor level, other uses can be made of this bay. For safety reasons, the spin balance machine control room is separate from the spin room. Television cameras are used for remote monitoring of spin room activities.

A control room is located next to each processing high bay to facilitate monitoring and control of hazardous operations. Visual contact with the high bay is through an explosion-proof glass window in the separating wall. Access to the high bay area from the control room is through the garment room while spacecraft processing operations are being conducted.

North and south encapsulation bays support off-pad encapsulation operations for 4-m-fairing missions. Both encapsulation bays are airlock/high bays providing outside access to the facility plus processing capability to support spacecraft processing and encapsulation. To maintain a cleanroom environment, personnel access to both encapsulation bays can be limited to using the west garment room. The south encapsulation bay leads to the south airlock, and the north encapsulation bay leads to the north high bay. The north encapsulation bay is 12.2 m by 15.2 m (40 ft by 50 ft) and has a 27 216-kg (30-ton) crane with a 16.8-m (55-ft) hook height. The south encapsulation bay is 13.7 m by 21.3 m (45 ft by 70 ft) and has a 27 216-kg (30-ton) crane with a 17.1-m (56-ft) hook height.

Adjacent to the south high bay, fuel and oxidizer cart storage rooms are provided with access doors to the high bay and exterior doors for easy equipment access. Garment rooms provide

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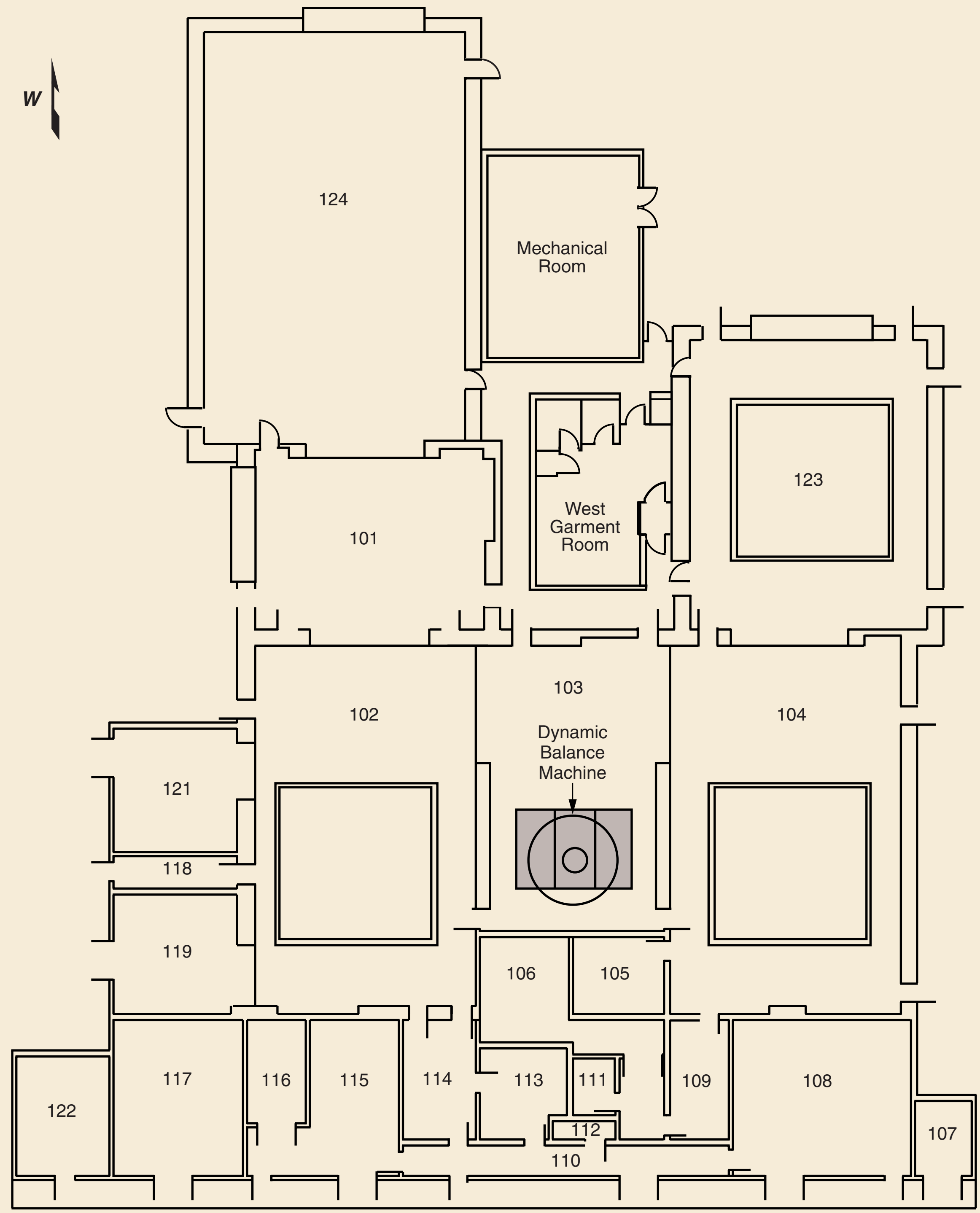


| | | | |
|---|---|---|---|
| 101 South Airlock | 108 North Control Room | 115 South Control Room | 120 Not Used |
| 102 South High Bay | 109 North Change Room | 116 Balance Machine Control Room | 121 Fuel Cart Storage Room |
| 103 Center High Bay | 110 Corridor | 117 Mechanical Room 1 | 122 Electrical Vault |
| 104 North High Bay | 111 Womens Restroom | 118 Corridor | 123 Building 2A – North Airlock Encapsulation Bay |
| 105 Office | 112 Janitor | 119 Oxidizer Cart Storage Room | 124 South Encapsulation Bay |
| 106 Mechanical Room 2 | 113 Mens Restroom | | |
| 107 Motor Generator Room | 114 South Change Room | | |

**Figure 6-7. Building 2 (HPF) Detailed Floor Plan, Astrotech**

personnel access and support to the high bay areas. Limiting access to the high bays through these rooms helps control personnel traffic and maintains a clean-room environment.

**6.2.1.3 Astrotech Building 3 (Environmental Storage Facility).** The dimensions of building 3 (Figure 6-8) are 15.8 m by 21.6 m (52 ft by 71 ft). The building is divided into six storage bays. Four are 7.6 m by 6.76 m (25 ft by 22 ft), and two are 7.6 m by 7.3 m (25 ft by 24 ft). Each has a clear vertical height of 8.5 m (28 ft). The bays have individual environmental control but are not cleanrooms, which mandates that payloads be stored in suitable containers.

**6.2.1.4 Astrotech Building 4 (Warehouse Storage Facility).** Building 4 (Figure 6-9) is 18.9 m by 38.1 m (62 ft by 125 ft) with a maximum roof height of 9.1 m (30 ft). The major areas of building 4 are the warehouse storage area, bonded storage area, and Astrotech staff office area.

The main warehouse storage area measures 15.2 m by 38.1 m (50 ft by 125 ft) and has a clear vertical height that varies from 8.5 m (28 ft) along either sidewall to 9.7 m (32 ft) along the lengthwise centerline of the room. The storage area is protected from the outside weather, but there is no environmental control.

The bonded storage area is environmentally controlled and has a floor area measuring 3.6 m by 9.7 m (12 ft by 32 ft).

**6.2.1.5 Astrotech Building 5 (Owner/Operator Office Area).** Building 5 (Figure 6-10) provides office and conference rooms for the spacecraft project.

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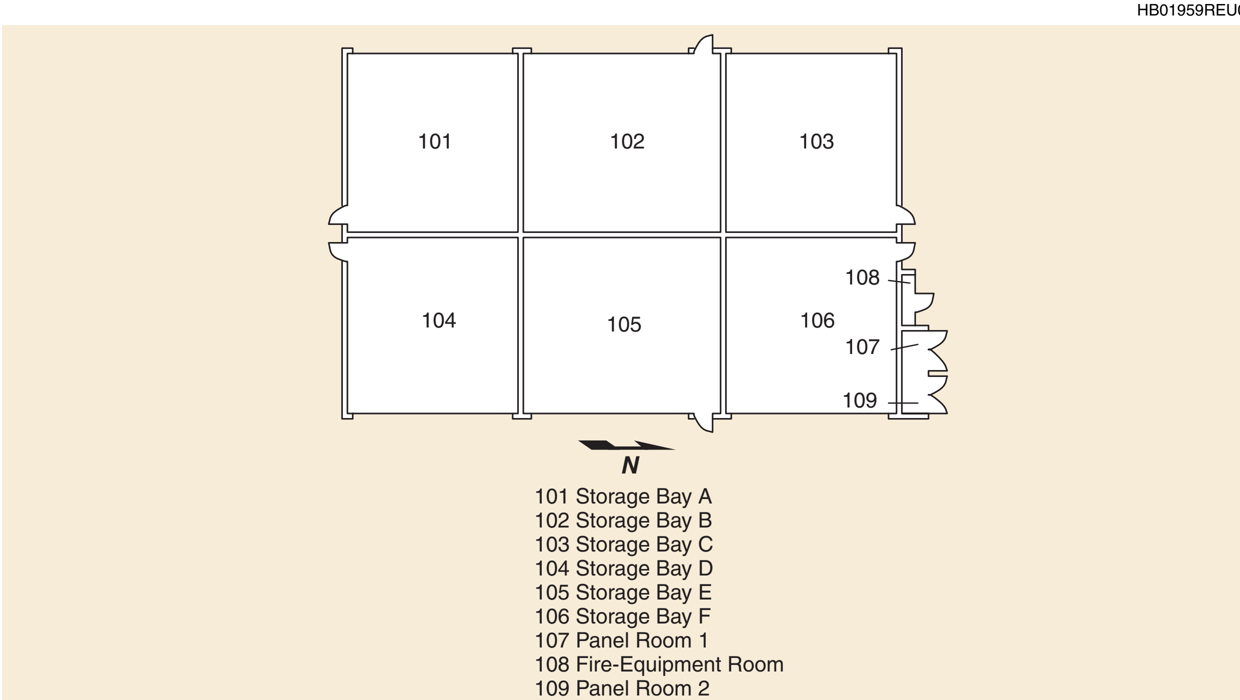


**Figure 6-8. Building 3 Detailed Floor Plan, Astrotech**

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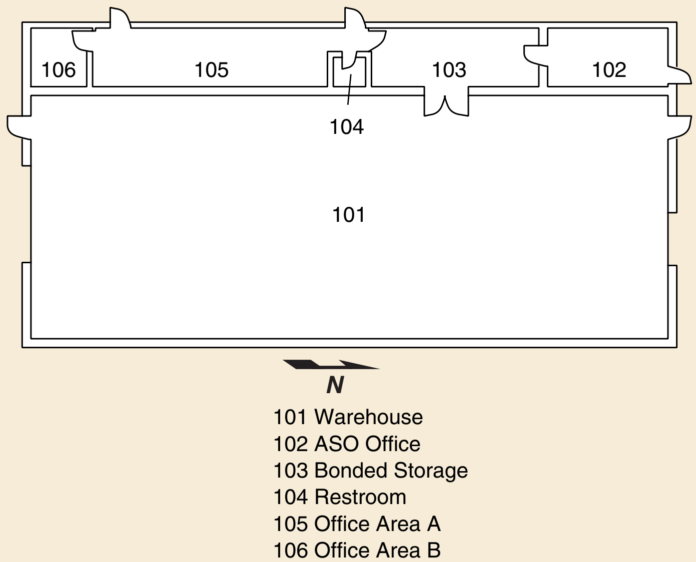


**Figure 6-9. Building 4 Detailed Floor Plan, Astrotech**

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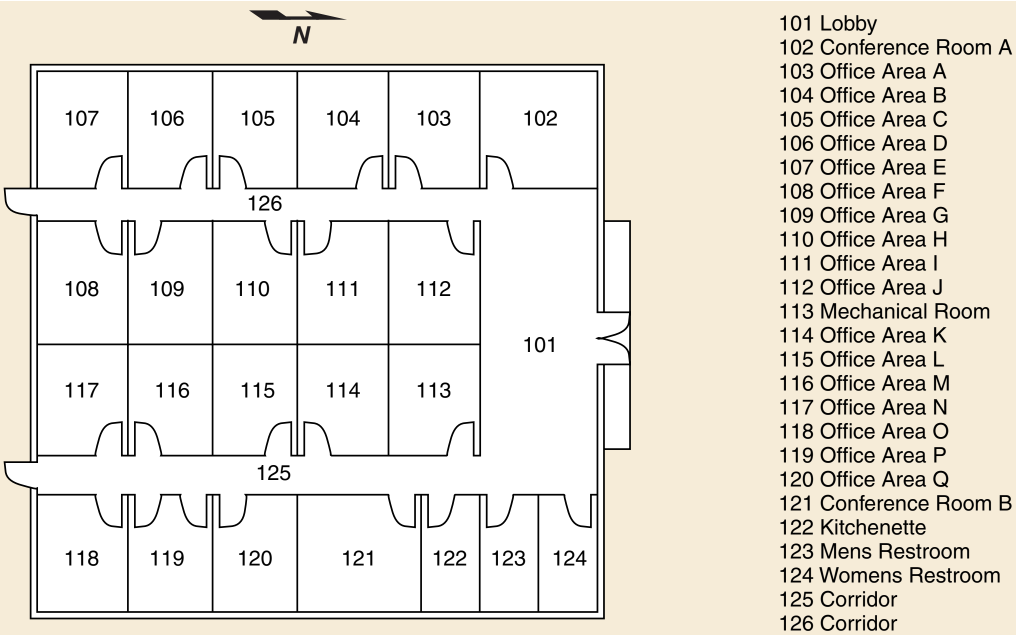


**Figure 6-10. Building 5 Detailed Floor Plan, Astrotech**

**6.2.1.6 Astrotech Building 6 (Fairing Support Facility).** Building 6 (Figure 6-11) consists of a warehouse area and a bonded storage area. The overall plan dimensions of building 6 are 15.2 m by 18.3 m (50 ft by 60 ft) with maximum roof height of 12.2 m (40 ft).

**6.2.1.7 Astrotech Building 7 (Boeing Office Area).** This area provides Boeing launch team members with office space during their activities at Astrotech.

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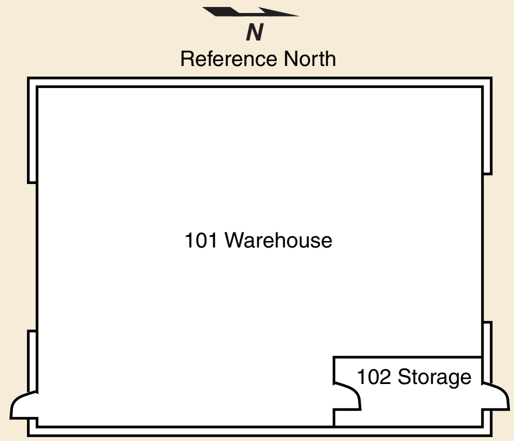


| Room | Function | Length | Width | Height | Doorway |
|---|---|---|---|---|---|
| 101 | Warehouse | 18.3 m (60 ft) | 15.2 m (50 ft) | 12.2 m (40 ft) | 6.1 m by 12.2 m (20 ft by 40 ft) |
| 102 | Storage | 6.1 m (20 ft) | 3.1 m (10 ft) | 2.4 m (8 ft) | 0.9 m by 2.0 m (3.0 ft by 6.8 ft) |

Notes:
1. All dimensions are approximate and shown as meters (feet).
2. The walls and ceilings in the warehouse are made of poly-covered insulation. The floor is made of concrete.

**Figure 6-11. Building 6 Detailed Floor Plan, Astrotech**

**6.2.1.8 Astrotech Building 8 (Launch Operations Storage Building).** This building provides storage space for customers to prepare for launch campaigns.

**6.2.1.9 Astrotech Building 9 (Delta IV Payload Processing Facility).** Building 9 has the capabilities to support 5-m payload fairing mission operations. Major features are two spacecraft processing cells, an encapsulation bay, three control rooms, a common airlock, a fairing processing bay, and two propellant cart rooms. The Delta IV payload processing facility is designed to support all spacecraft processing activities including propellant loading operations. It supports class 100,000 cleanliness standards and has the ability to achieve class 10,000 cleanliness using strict operational controls. The floor plan of building 9 is shown in Figure 6-12.

The spacecraft processing cells are hazardous processing bays designed and outfitted to support propellant operations. They each have 15.2-m by 18.3-m (50-ft by 60-ft) clear floor areas. Both cells have a crane with a 22.3-m (73-ft) hook height. The west cell has a crane capacity of 27 216 kg (30 tons), and the east cell has a crane capacity of 22 680 kg (25 tons). Each cell has a dedicated control room, and they share a garment room.

The encapsulation processing bay is a hazardous processing bay designed to support encapsulation operations for all 5-m-fairing configurations. Propellant loading support systems are provided to support contingency loading/offloading operations. The bay has a floor area of 19.8 m by 24.4 m (65 ft by 80 ft) and a crane capacity of 45 360 kg (50 tons) with a 30.5-m (100-ft) hook height. This bay has its own control room and garment room.

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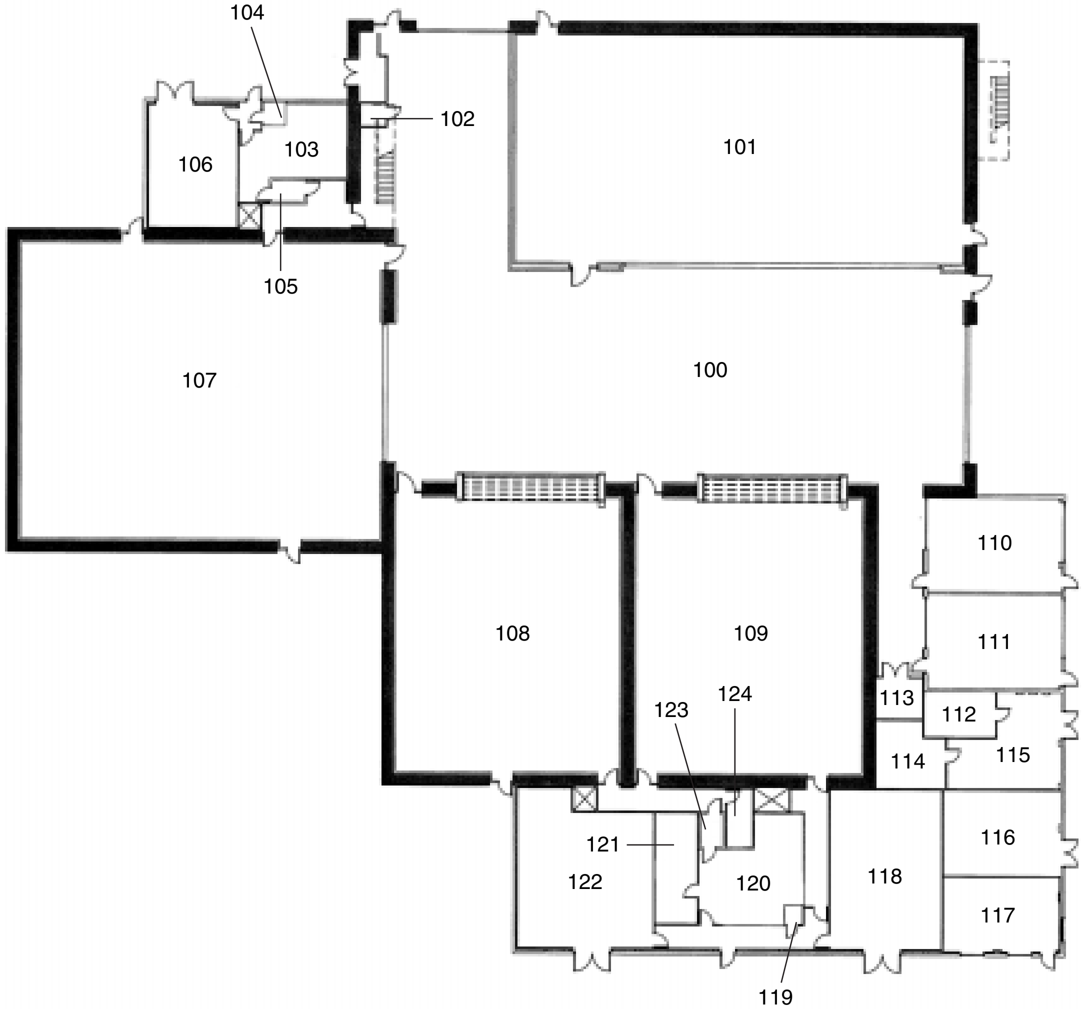


| | | |
|---|---|---|
| 100 Common Airlock | 108 Process Cell 1 | 117 Break Room |
| 101 Fairing Processing Bay | 109 Process Cell 2 | 118 Control Room 3 |
| 102 Janitor | 110 Propellant Cart Room 1 | 119 Janitor |
| 103 Garment Room 1 | 111 Propellant Cart Room 2 | 120 Garment Room 2 |
| 104 Janitor | 112 UPS Room | 121 Garment Storage |
| 105 Airshower | 113 Storage Room | 122 Control Room 2 |
| 106 Control Room 1 | 114 Communications Room | 123 Airshower |
| 107 Encapsulation Bay | 115 Electricrical Room | 124 Janitor |
| | 116 MEP Room | |

**Figure 6-12. Building 9 Detailed Floor Plan – Astrotech**

Delta IV payload fairings and ground support equipment are stored in the fairing processing bay. The fuel and oxidizer propellant cart rooms are support areas for the thermal conditioning of propellant and decontamination of spacecraft loading equipment. They both measure 6.1 m by 9.1 m (20 ft by 30 ft). All processing areas, storage areas, and propellant cart rooms are accessible from the 13.7-m by 38.1-m (45-ft by 125-ft) common airlock, which has a crane capability of 27 216 kg (30 tons) with a 27.7-m (91-ft) hook height.

**6.2.1.10 Spacecraft Long-Term Storage.** Astrotech can provide long-term environmentally controlled storage for spacecraft contractors. For further information, contact Delta Launch Services.

### 6.2.2 CCAFS Operations and Facilities

Prelaunch operations and testing of Delta IV payloads at CCAFS take place in the Cape Canaveral industrial area and SLC-37.

**6.2.2.1 Cape Canaveral Industrial Area.** Delta IV payload support facilities are located in the CCAFS industrial and support area (Figure 6-13). USAF-shared facilities or work areas at CCAFS are available for supporting spacecraft projects and spacecraft contractors. These areas include the following:

- Solid propellant storage area.
- Explosive storage magazines.
- Electrical-mechanical testing facility.
- Liquid propellant storage area.

### 6.2.3 Delta Operations Center

All Delta IV launch operations will be controlled from the launch control center (LCC) in the Delta Operations Center (DOC). A spacecraft control room and office adjacent to the LCC is available during launch. Communication equipment in the computer room provides signal interface between the LCC, the launch pad, and the PPF (Figure 6-14).

### 6.2.4 Solid-Propellant Storage Area, CCAFS

The facilities and support equipment in this area are maintained and operated by USAF range contractor personnel, who also provide ordnance-item transport. Preparation of ordnance items for flight (i.e., safe-and-arm (S&A) devices and EEDs) is performed by spacecraft contractor personnel using spacecraft-contractor-prepared, range-safety-approved procedures. Range-contractor-supplied test consoles contain the items listed in Table 6-1. Tests are conducted according to spacecraft contractor procedures, approved by range safety personnel.

**6.2.4.1 Storage Magazines, CCAFS.** Storage magazines are concrete bunker-type structures located at the north end of the storage area. Only two magazines are used for spacecraft ordnance. One magazine is environmentally controlled to 23.9° ± 2.8°C (75° ± 5°F) with 65%

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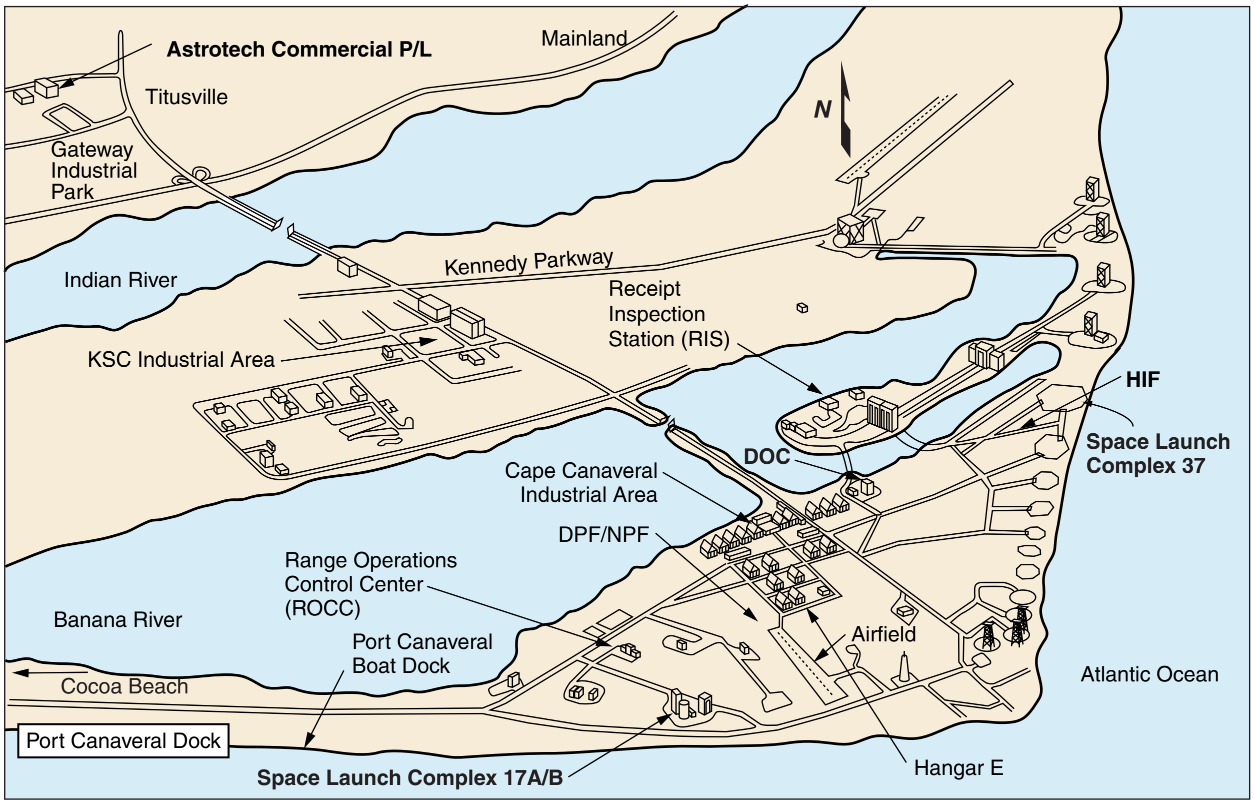


**Figure 6-13. Cape Canaveral Air Force Station (CCAFS) Facilities**

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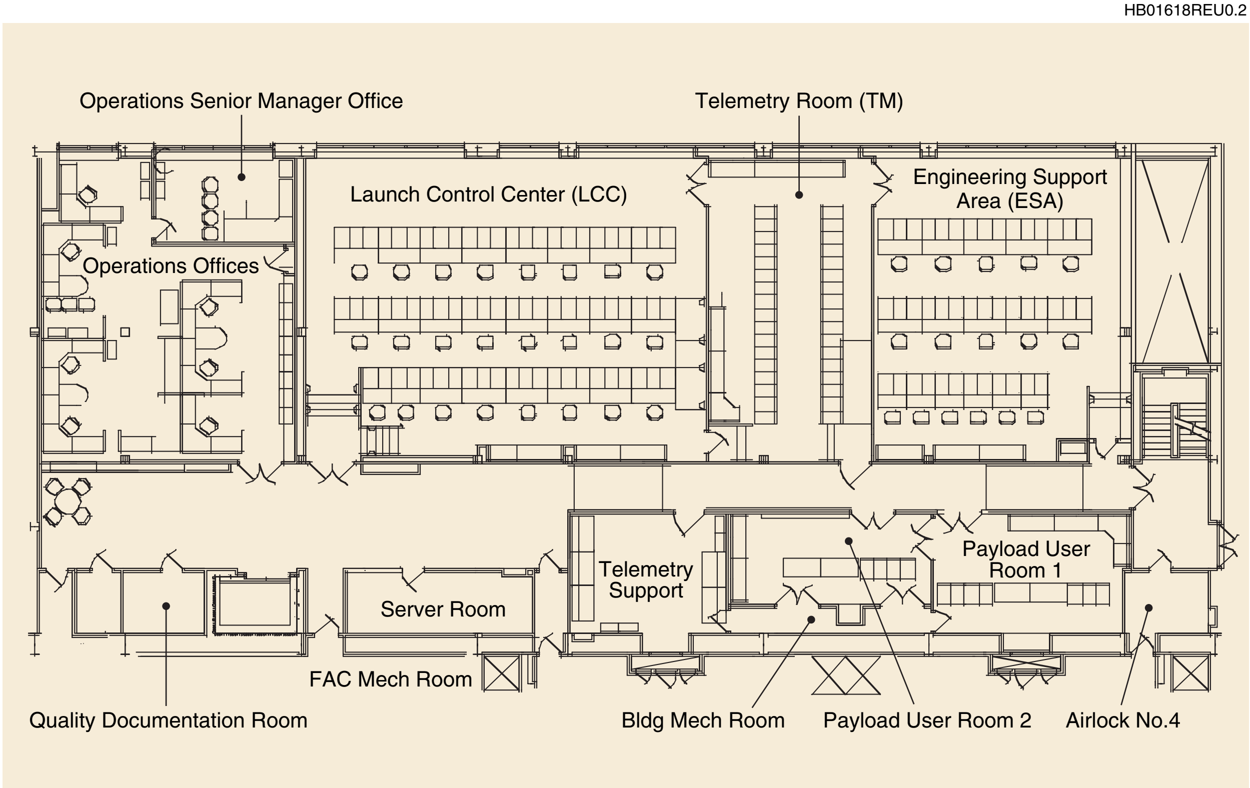


**Figure 6-14. Space Launch Complex 37 Launch Control Center (LCC)**

**Table 6-1. Test Console Items**

| | |
|---|---|
| Resistance measurement controls | Alinco bridge and null meter |
| Digital current meter | Resistance test selector |
| Digital voltmeter | Digital ammeter |
| Auto-ranging digital voltmeter | Digital stop watch |
| Digital multimeter | Relay power supply |
| High-current test controls | Test power supply |
| Power supply (5 V) | Power control panel |
| High-current test power supply | Blower |

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maximum relative humidity. This magazine contains small ordnance items such as S&A devices, igniter assemblies, initiators, bolt cutters, and electrical squibs. The other magazine is used for storage of solid-propellant motors. It is environmentally controlled to 29.4° ± 2.8°C (85° ± 5°F) with 65% maximum relative humidity.

**6.2.4.2 Electrical-Mechanical Testing Facility, CCAFS.** The electrical-mechanical testing (EMT) facility (Figure 6-15), operated by range contractor personnel, can be used for functions such as ordnance-item bridgewire resistance checks and S&A device functional tests, as well as for test-firing small self-contained ordnance items.

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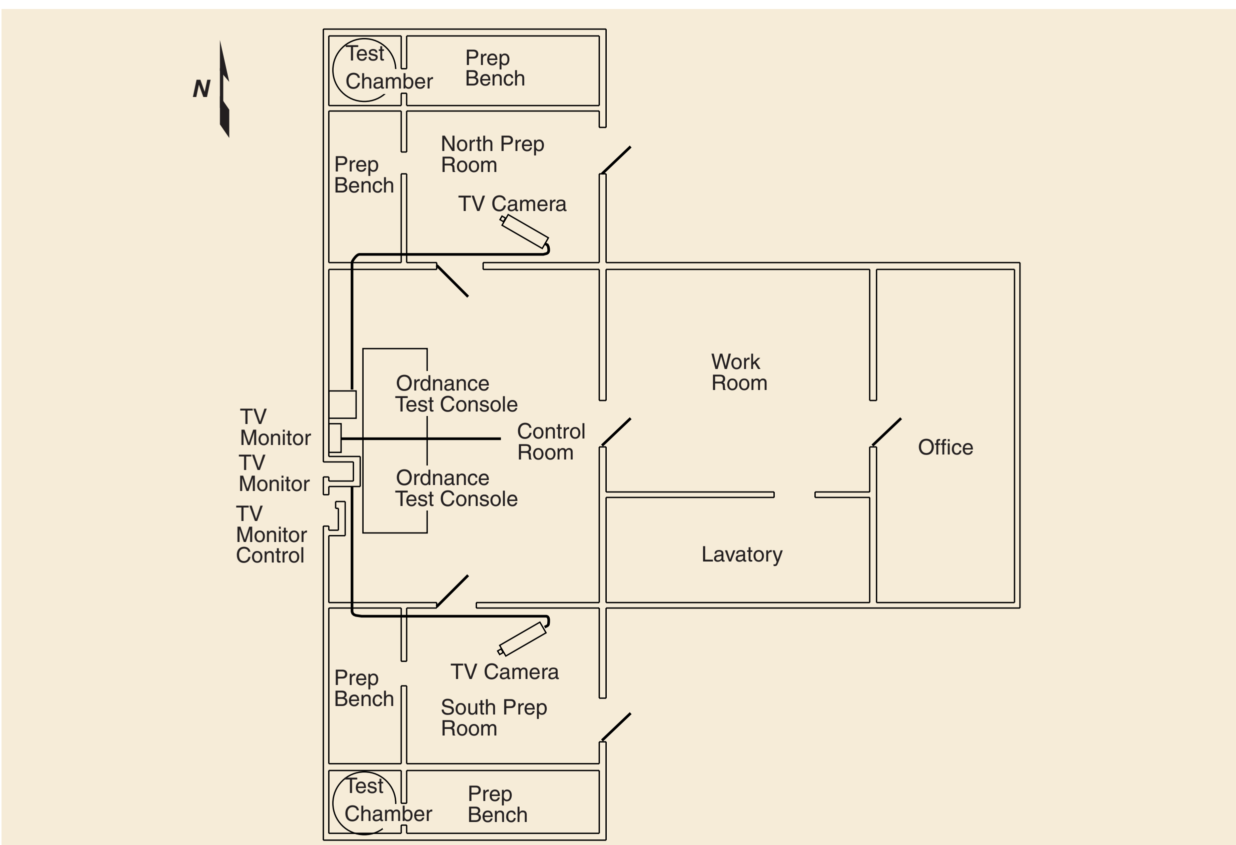


**Figure 6-15. Electrical-Mechanical Testing Building Floor Plan**

Existing electrical cables provide the interface between ordnance items and test equipment for most devices commonly used at CCAFS. These cables are tested before each use, and the test data are documented. If a cable or harness does not exist for a particular ordnance item, it is the responsibility of the spacecraft contractor to provide the proper mating connector for the ordnance item to be tested. Six weeks of lead time are required for cable fabrication.

## 6.3 SPACECRAFT ENCAPSULATION AND TRANSPORT TO THE LAUNCH SITE

As mentioned in Section 6.2, Delta IV provides fueled payload encapsulation in the fairing at the payload processing facilities (PPF): the USAF PPFs in the CCAFS industrial area for USAF payloads, NASA PPFs for NASA payloads, and, normally, ASO for commercial customers. This capability enhances payload safety and security while mitigating contamination concerns, and greatly reduces launch pad operations in the vicinity of the payload. In this document, discussions are limited to the ASO facility.

Payload integration with the PAF and encapsulation in the fairing are planned in the PPF of Astrotech building 2 for Delta IV launches that use the 4-m composite fairing and, in Astrotech building 9, for Delta IV launches that use the 5-m composite and metallic fairings. Details of the high bay, airlock, and adjacent control and equipment rooms for buildings 2 and 9 are given in Sections 6.2.1.2 and 6.2.1.9, respectively. The basic sequence of operations at Astrotech is illustrated in Figure 6-16.

Prior to payload arrival, the fairing and PAF(s) enter the high bay to be prepared for payload encapsulation. The fairing bisectors or trisectors are erected and stored on roll transfer dollies. The PAF is installed on the Boeing buildup stand and prepared for payload mate. After payload arrival and premate operations are completed, including payload weighing if required in lieu of a certified weight statement, the payload is mated to the PAF, and integrated checkout is performed. The previously prepared fairing bisectors or trisectors are rolled into position for final mate, and the personnel access stands are positioned for personnel access to the fairing mating plane. These access stands can also be used for payload access prior to fairing mate. Interface connections are made and verified. A final payload telemetry test, through the fairing, can be accommodated at this time. The encapsulated payload is transferred to the transporter provided by Boeing and prepared for transport to the launch pad. Environmental controls are established, and a protective road barrier is installed.

After arrival at SLC-37, environmental control is discontinued and the encapsulated payload is lifted into the mobile service tower (MST) and immediately mated to the second stage. Environmental control is reestablished as soon as possible with class-5000 air while the MST enclosure is closed and secured. Should subsequent operations require access through the fairing, a portable clean-environment shelter will be erected over the immediate area to prevent payload contamination.

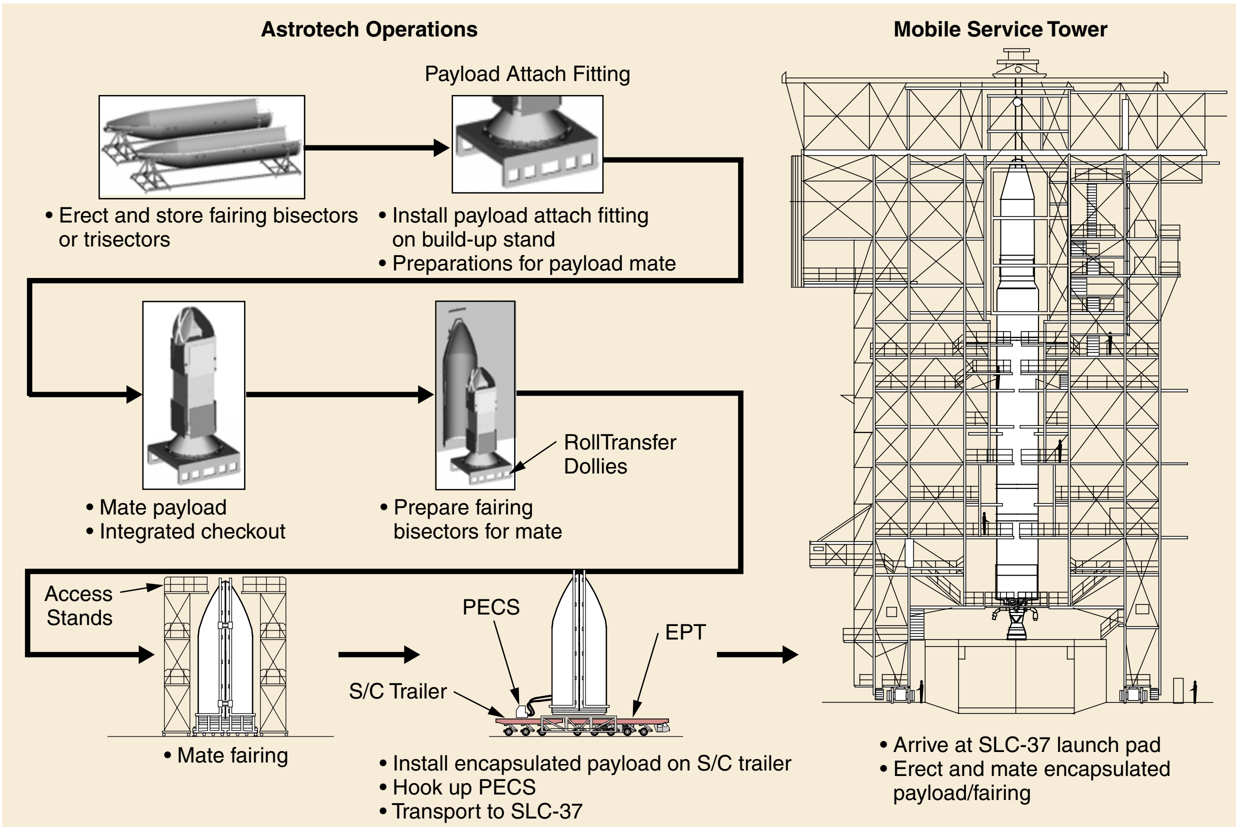


**Figure 6-16. Payload Encapsulation, Transport, and On-Pad Mate**

The six Eastern Range payload processing facilities that are adequate for encapsulation operations with/without modification are listed in Table 6-2.

Potential PPFs and their facility specifications are outlined in the Payload Processing Facility Matrix (Table 6-3).

## 6.4 SPACE LAUNCH COMPLEX 37

SLC-37 is located in the northeastern section of CCAFS (Figure 6-13) between SLC 36 and SLC 41. It consists of one launch pad (pad B), a mobile service tower (MST), a fixed umbilical tower (FUT), a common support building (CSB), a support equipment building (SEB), ready room, shops, and other facilities needed to prepare, service, and launch the Delta IV vehicles.

**Table 6-2. Eastern Range Payload Processing Facilities**

| Facility | Location | Encapsulation capability |
|---|---|---|
| Vertical processing facility (VPF) | Kennedy Space Center, FL | 4-m and 5-m fairings |
| Multi-payload processing facility (MPPF) | Kennedy Space Center, FL | 4-m fairings |
| Payload hazardous processing facility (PHPF) | Kennedy Space Center, FL | 4-m and 5-m fairings |
| DSCS processing facility (DPF) | Cape Canaveral Air Force Station, FL | 4-m fairings |
| Shuttle payload integration facility (SPIF) | Cape Canaveral Air Force Station, FL | 4-m and 5-m fairings |
| Astrotech Space Operations | Titusville, FL | 4-m and 5-m fairings |

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**Table 6-3. Payload Processing Facility Matrix**

| Facility | Location | No. payload (cap.) | Work area/bay cleanliness classification size (W by L by H) | Bay access opening (W by H) | Bay hoist equipment max. hook height | Airlock size (W by L by H) | Airlock access opening (W by H) | Airlock hoist equip. max. hook height | Other information | Encap. compatibility |
|---|---|---|---|---|---|---|---|---|---|---|
| Vertical processing facility (VPF)<br>Note<br>Deactivated: Use of this facility requires notice to NASA for activation. | KSC, FL | 2 | Class 100,000<br>22.9 m x 45.7 m x 29.6 m<br>(75 ft by 150 ft by 97 ft) | 11.6 m by 21.7 m<br>(38 ft by 71 ft 4 in.) | 22 675-kg (25-ton) bridge<br>28.7-m (94 ft) hook height<br>10 884-kg (12-ton) bridge<br>28.4-m (93 ft) hook height | 12.8 m by 22.9 m by 22.6 m<br>(42 ft by 75 ft by 74 ft) | 7.5 m by 21.6 m<br>(24 ft 9 in. by 71 ft) | 9070-kg (10-ton) monorail<br>20-m (65-ft 8-in.) hook height | | 4-m fairings<br>5-m fairings (limited) |
| Multi-payload processing facility (MPPF) | KSC, FL | Multiple | Class 100,000<br>low bay: 10.4 m by 10.4 m by 9.1 m<br>(34 ft by 34 ft by 30 ft)<br>High bay: 40.2 m by 18.3 m by 18.9 m<br>(132 ft by 60 ft by 62 ft) | High bay door (external entry door): 8.5 m by 12.8 m (28 ft by 42 ft)<br>Low bay door: 6.1 m by 4.6 m<br>(20 ft by 15 ft) | 18 140-kg (20-ton) bridge<br>14.9-m (49 ft) hook height | Class 300,000<br>11.9 m by 8.5 m by 6.1 m (39 ft by 28 ft by 20 ft) | 6.1 m by 4.6 m<br>(20 ft by 15 ft) | None | 6.1 m by 5.5 m by 3.7 m<br>(20 ft by 18 ft by 12 ft)<br>horiz. laminar flow 100k CWA | 4-m fairings |
| Payload hazardous processing facility (PHPF) | KSC, FL | 1 | Class 100,000<br>32.6 m by 18.4 m by 28.9 m<br>(107 ft by 60 ft 4 in. by 94 ft 10 in.) | 10.8 m by 22.9 m<br>(35 ft 5 in. by 75 ft) | 45 380-kg (50-ton) bridge<br>25.3-m (83-ft) hook height | Class 300,000<br>25.9 m by 15.3 m by 27.4 m<br>(85 ft by 50 ft 4 in. by 89 ft 10 in.) | 10.8 m by 22.9 m<br>(35 ft 5 in. by 75 ft) | 13 600-kg (15-ton) bridge<br>22.9-m (75-ft) hook height | | 4-m fairings<br>5-m fairings |
| DSCS processing facility (DPF) | CCAFS, FL | TBD (2) | Class 100,000<br>Main bay: 15.2 m by 30.5 m by 7.6 m (50 ft by 100 ft by 25 ft)<br>Encapsulation bay: 15.2 m by 15.2 m by 19.8 m (50 ft by 50 ft by 65 ft)<br>Fueling bay: 15.2 m by 15.2 m by 19.8 m<br>(50 ft by 50 ft by 65 ft) | Main bay: 6.1 m by 6.1 m (20 ft by 20 ft)<br>Encapsulation bay: 6.1 m by 15.2 m (20 ft by 50 ft)<br>Fueling bay: 6.1 m by 15.2 m (20 ft by 50 ft) | Main bay: 4535-kg (5-ton) bridge<br>6.1-m (20-ft) hook height<br>Encapsulation bay: (TBD)<br>Fueling bay: 13 600-kg (15-ton) bridge<br>16.8-m (55-ft) hook height | Class 100,000<br>15.2 m by 15.2 m by 19.8 m<br>(50 ft by 50 ft by 65 ft) | 6.1 m by 15.2 m<br>(20 ft by 50 ft) | 13 600-kg (15-ton) bridge<br>16.8-m (55-ft) hook height | | 4-m fairings |

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**Table 6-3. Payload Processing Facility Matrix (Continued)**

| Facility | Location | No. payload (cap.) | Work area/bay cleanliness classification size (W by L by H) | Bay access opening (W by H) | Bay hoist equipment max. hook height | Airlock size: (W by L by H) | Airlock access opening (W by H) | Airlock hoist equip. max. hook height | Other information | Encap. compatibility |
|---|---|---|---|---|---|---|---|---|---|---|
| Shuttle payload integration facility (SPIF) | CCAFS, FL | 2 | Class 100,000<br>Integration cells: 9.32 m by 11.2 m by 23.2 m (30 ft 7 in. by 36 ft 9 in. by 76 ft)<br>Transfer aisle: 11.6 m by 23.5 m (38 ft by 77 ft by 119 ft) | Integration cells: 6.1 m by 23 m (20 ft by 75 ft 6 in.)<br>Transfer aisle: 7 m by 22.3 m (23 ft by 73 ft) | Transfer aisle/ integration cells: 45 360-kg (50-ton) bridge w/9070-kg (10-ton) aux. 30.4-m (100-ft) hook height | Class 100,000<br>Canister airlock<br>7 m by 12.2 m by 24.4 (23 ft by 40 ft by 80 ft) | 7 m by 22.3 m (23 ft by 73 ft) | None | | 4-m fairings<br>5-m fairings (limited) |
| Astrotech Space Operations | Titusville, FL | Multiple | Class 100,000<br>N. high bay: 11.3 m by 18.3 m by 13.1 m (37 ft by 60 ft by 43 ft)<br>S. high bay: 11.3 m by 18.3 m by 13.1 m (37 ft by 60 ft by 43 ft) | Both bays: 6.1 m by 12.2 m (20 ft by 40 ft) | 19 070-kg (10-ton) bridge common to north/south and spin bays 11.3-m (37-ft) hook height | N. airlock<br>12.2 m by 16.8 m by 19.8 m (40 ft by 55 ft by 65 ft) | 6.1 m by 15.2 m (20 ft by 50 ft) | 27 220-kg (30-ton) bridge 16.8-m (55-ft) hook height | 4-m fairing encapsulation in airlock | 4-m fairings<br>5-m fairings |

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The pad can launch any of the five Delta IV vehicle configurations. Arrangement of SLC-37 is shown in Figure 6-17.

Because all operations in the launch complex involve or are conducted in the vicinity of liquid or solid propellants and explosive ordnance devices, the number of personnel permitted in the area, the safety clothing to be worn, the types of activities permitted, and equipment allowed are strictly regulated. Adherence to all safety regulations specified in Section 9 of this document is required. Boeing provides mandatory safety briefings on these subjects for persons required to work in the launch complex area.

### 6.4.1 Mobile Service Tower (MST)

The MST (Figure 6-18) is used to provide environmental protection and access to the launch vehicle after mating it to the launch table in the vertical position. The MST houses a 45 360-kg (50-ton) overhead bridge crane with a 91.5-m (300-ft) hook height capacity used during solid rocket motor mating and payload hoisting/mating operations.

The MST moves on rails to the service position (launch vehicle), using a hydraulic drive system, after the launch vehicle is mated to the launch table. Pneumatically and hydraulically operated work

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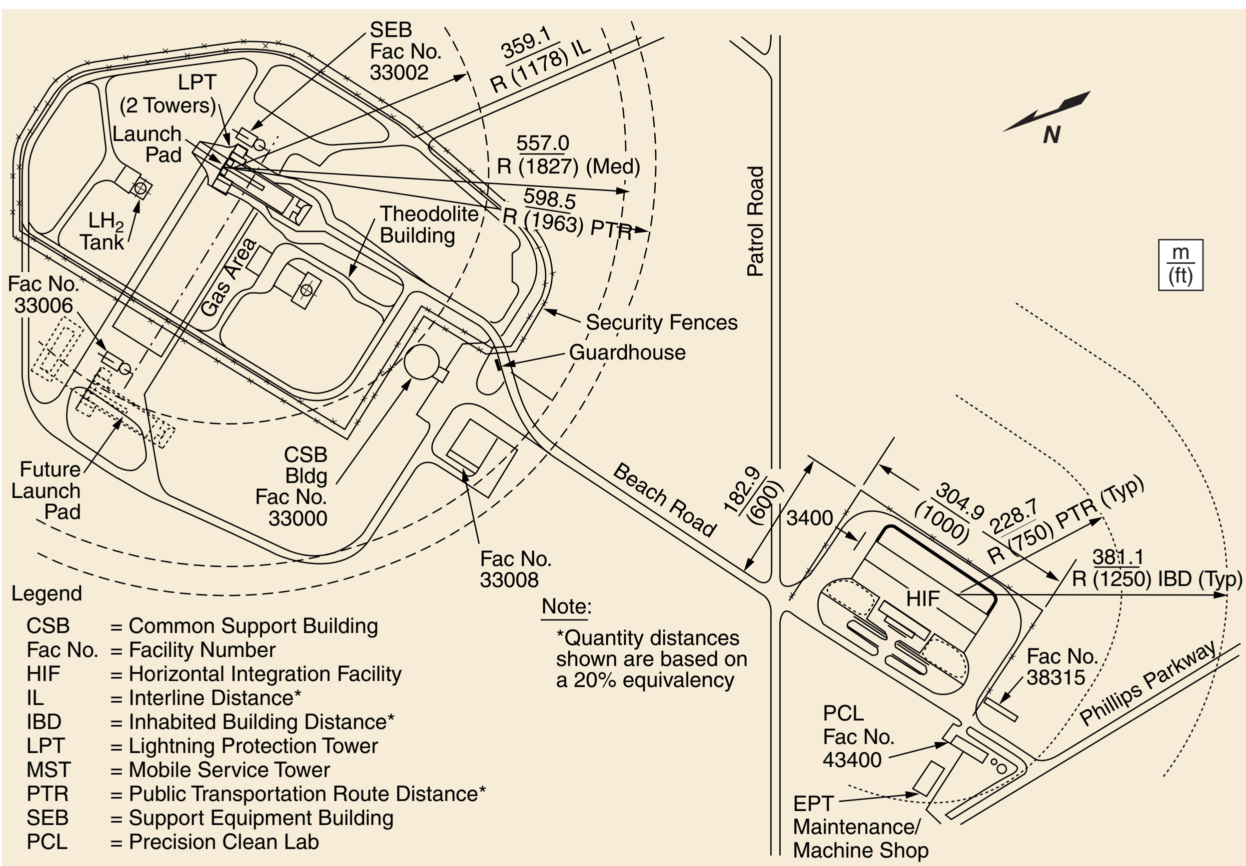


**Figure 6-17. Space Launch Complex 37, CCAFS**

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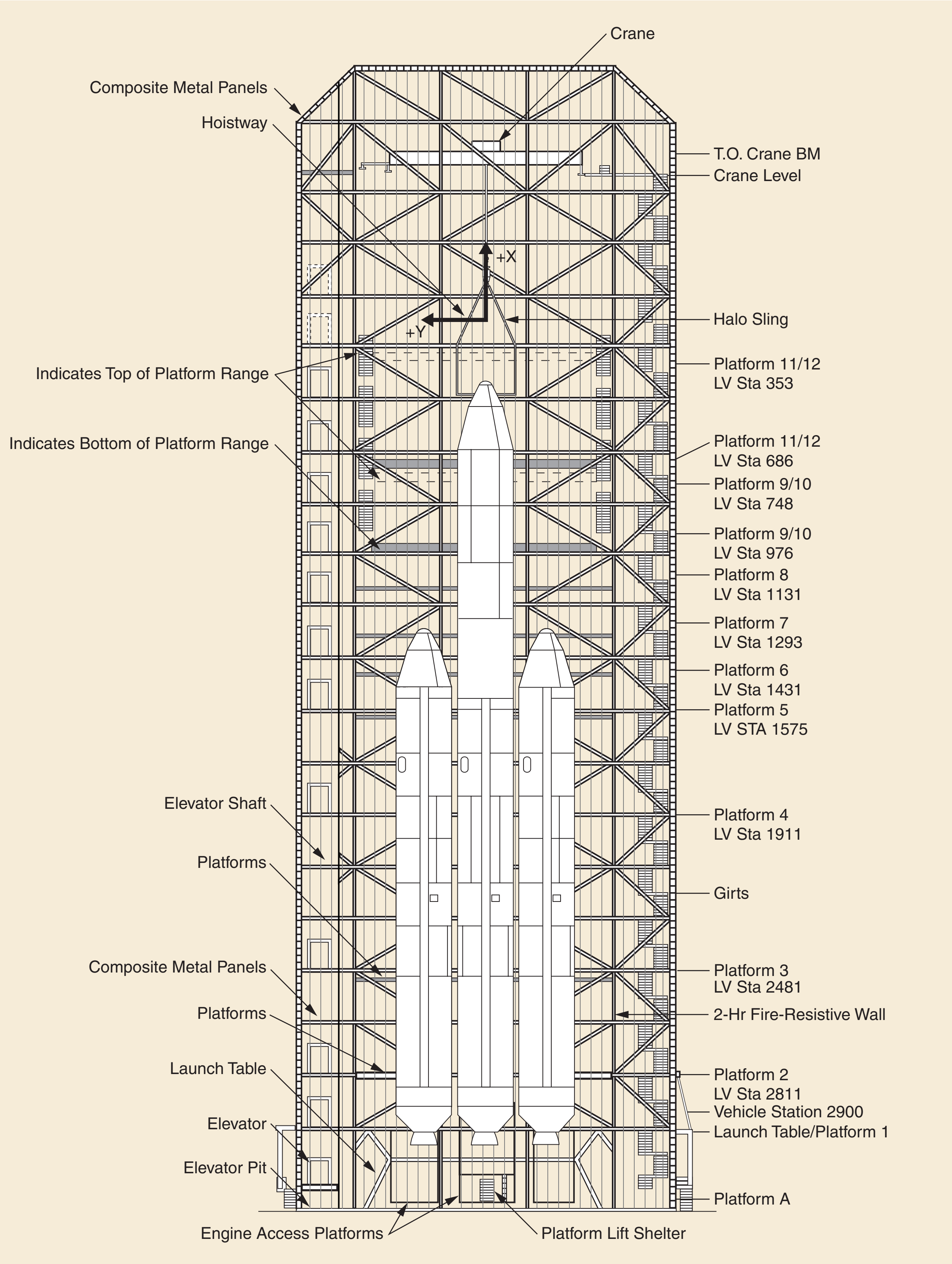


**Figure 6-18. Space Launch Complex 37 Mobile Service Tower (MST)**

platforms are lowered to access the launch vehicle and payload during integration assembly and final checkout. The work platforms are raised to clear the launch vehicle, and the MST is rolled to the parked position and cleared of all personnel during final launch countdown.

The work platforms on levels 5 through 7 provide a weather-protected area for launch vehicle innerstage access. The work platforms on levels 8 through 12 provide a weather-protected, climate-controlled area for upper-stage and payload checkout. There is a payload users room located on level 8 that customers can use to house electrical ground support equipment. This room is 3.05 m by 6.10 m by 4.12 m high (10 ft by 20 ft by 13.5 ft high) with a 0.88-m by 2.1-m (2.9-ft by 6.9-ft) door. The room can support a floor loading of 366.18 kg/m$^2$ (75 lb/ft$^2$) and point loading of 907.2 kg (2000 lb) distributed over a 0.76-m by 0.76-m (2.5-ft by 2.5-ft) area. The work platform floor plan for level 8 is shown in Figure 6-19. The movable work platform floor plans for levels 9 through 12 are shown in Figures 6-20 and 6-21.

### 6.4.2 Fixed Umbilical Tower (FUT)

The FUT is the 73.15-m (240-ft) steel structure located on the southwest corner of the launch deck. Three swing arm (SA) assemblies are attached to the northeast corner of the FUT at levels 7, 10, and 12. Swing arm No. 1 (level 7) connects umbilical cables and propellant lines to the centerbody of the common booster core. Swing arm No. 2 (level 10) connects umbilicals and propellant lines to the launch vehicle's upper stage. Swing arm No. 3 (level 12) connects an air-conditioning duct to the launch vehicle's payload fairing.

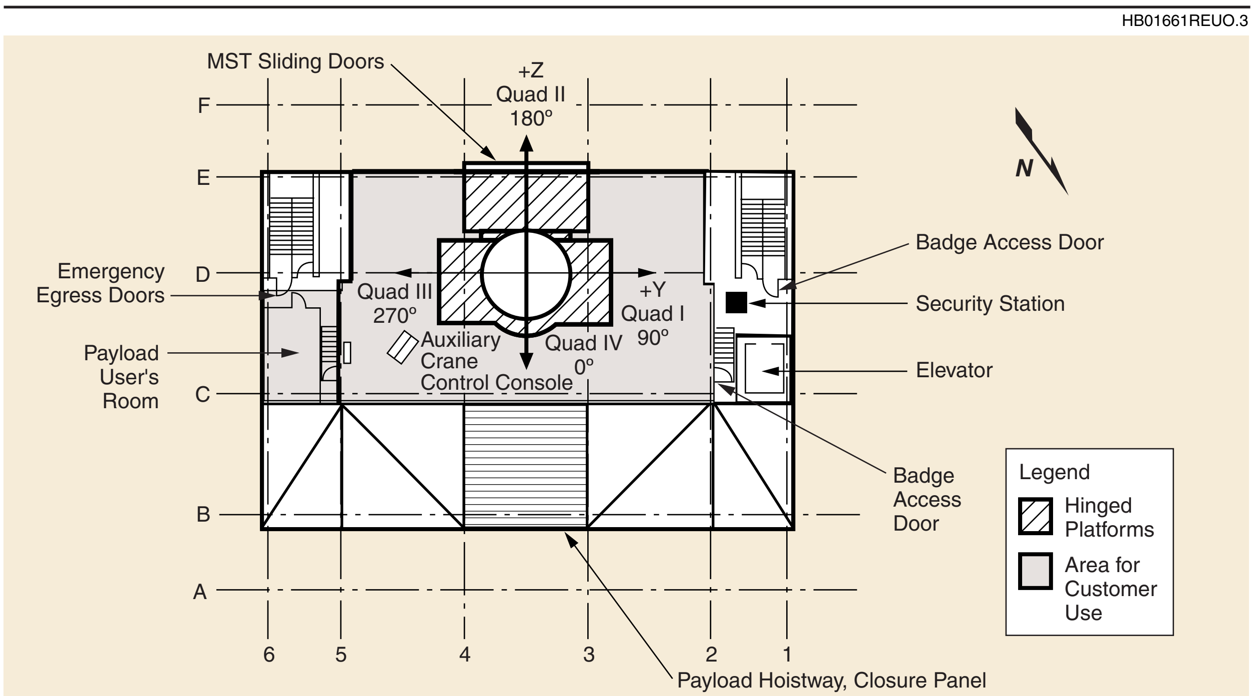


Figure 6-19. Fixed Platform (Level 8)

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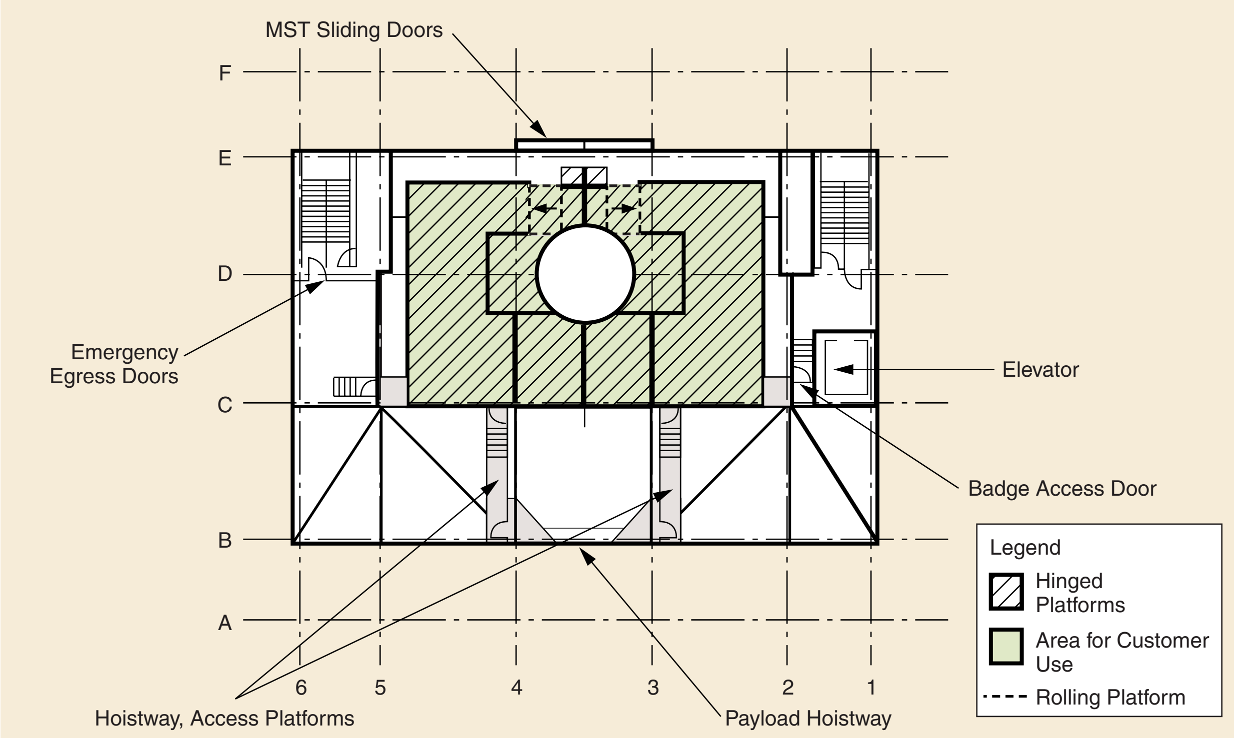


**Figure 6-20. Adjustable Platform (Levels 9 and 10)**

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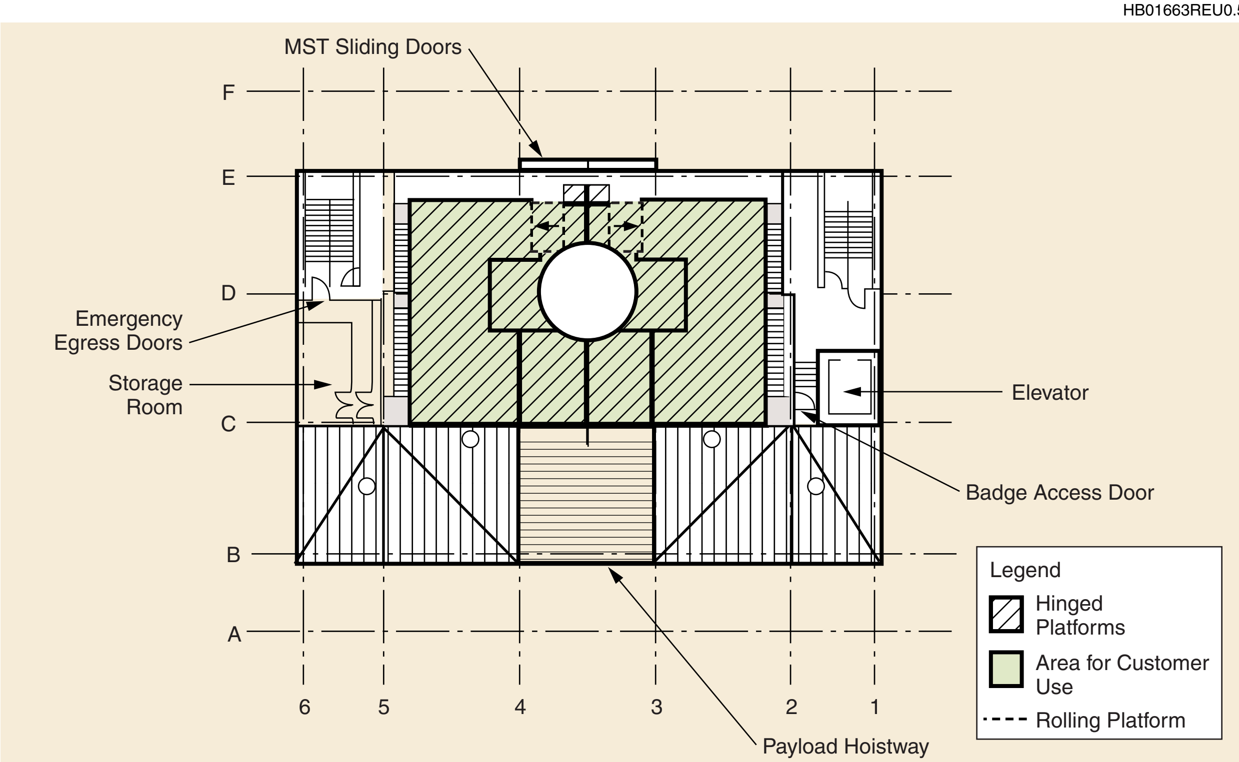


**Figure 6-21. Adjustable Platform (Levels 11 and 12)**

The FUT houses a hydraulic pump unit (HPU) that controls swing arm movement during testing and launch. Liquid oxygen ($LO_2$) and liquid hydrogen ($LH_2$) transfer pump assemblies are located on the FUT middle levels. Steel siding is installed on the north and east sides of the FUT to lend additional protection to installed equipment located on the structure.

### 6.4.3 Common Support Building (CSB)

The CSB contains the offices, supply rooms, tool rooms, break rooms, locker rooms, and other similar functional spaces necessary to support personnel at the launch pad. Existing facility 33000, which served as the launch control center for SLC-37, has been modified to provide space for these activities. This structure is not occupied during launch (Figures 6-17 and 6-22).

### 6.4.4 Support Equipment Building (SEB)

Facility 33002, the existing building at complex 37B, is used as the SEB (Figures 6-17 and 6-23). The SEB contains the payload, launch vehicle and facility air-conditioning equipment, and electrical and data communications equipment needed near the launch vehicle. All equipment is new. The SEB also includes minimal personnel support areas such as small restrooms and a small break room. The personnel support items are sized to support the limited number of personnel expected to be working

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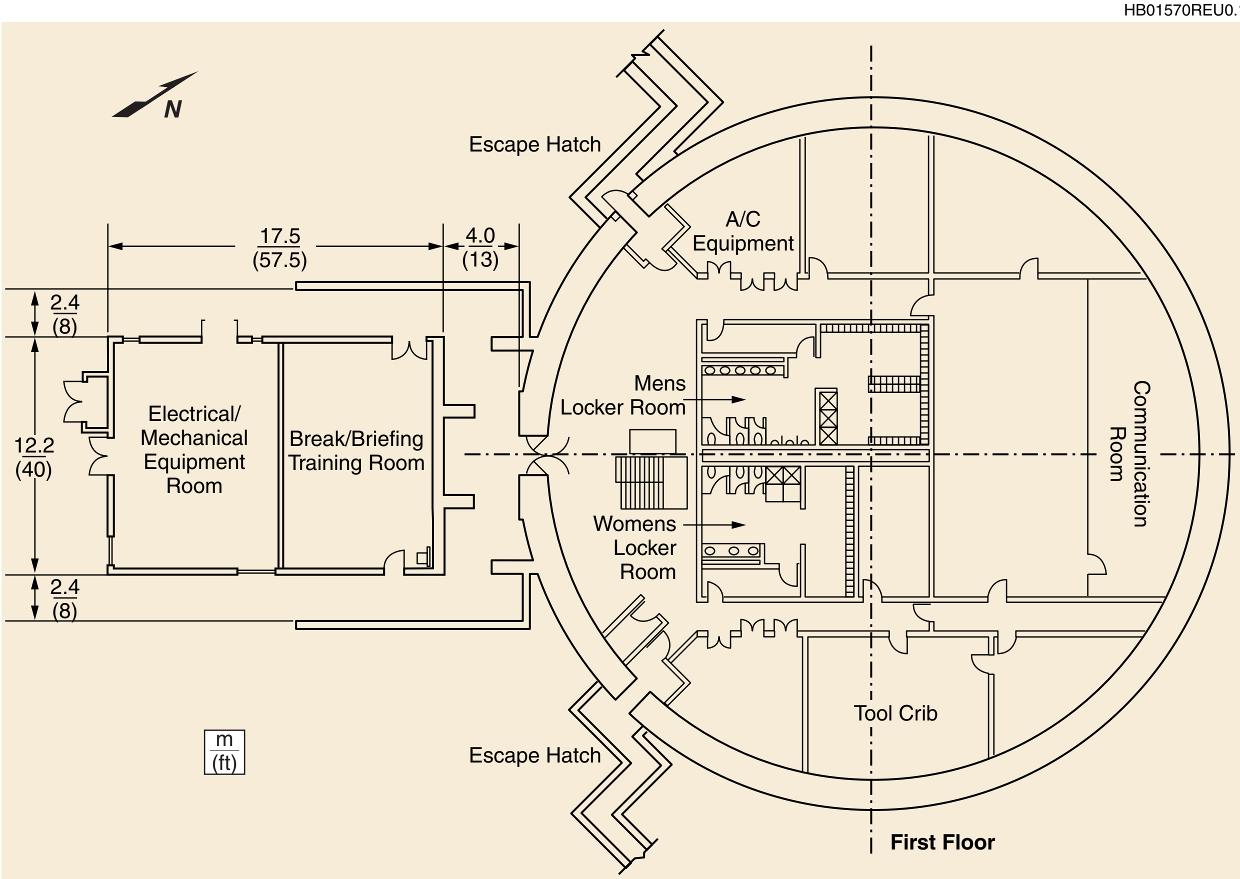


**Figure 6-22. Space Launch Complex 37 Common Support Building (CSB) Sample Layout**


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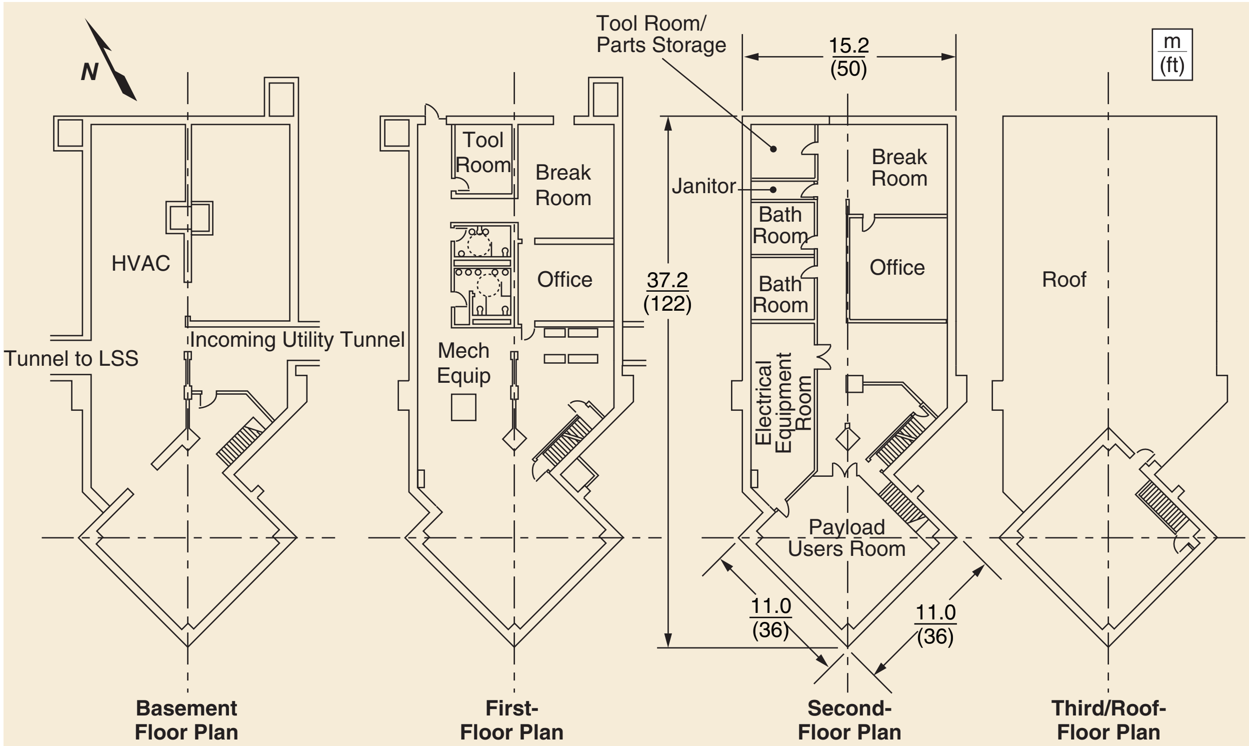


**Figure 6-23. Space Launch Complex 37 Support Equipment Building (SEB)**

on the pad at any one time. Limited office space and some parts storage facilities will be provided. This structure is not occupied during launch.

### 6.4.5 Horizontal Integration Facility (HIF)

Although not part of the SLC-37 complex, the HIF (Figures 6-17, 6-24, and 6-25) is used to process the launch vehicles after their transport from the receiving and storage facility. Work areas are used for assembly and checkout to provide fully integrated launch vehicles ready for transfer to the launch pad. The HIF has two bays to accommodate four single-core Delta IV-M and Delta IV-M+ process areas or two single-core Delta IV-M and Delta IV-M+ process areas and a Delta IV-H process area. Each bay is 76.2 m by 30.5 m (250 ft by 100 ft). Each bay has one 22 675-kg (25-ton) utility bridge crane. Both bays have a 22.6-m (74-ft) door on each end.

The HIF has space for support activities such as shipping and receiving, storage for special tools and supplies, and calibration and battery labs. The HIF annex provides an additional staging and LMU refurbishment area.

HIF offices are for administrative and technical personnel. A conference room is also provided. Employee support facilities include a training room, breakroom, locker rooms, and restrooms (Figure 6-24).

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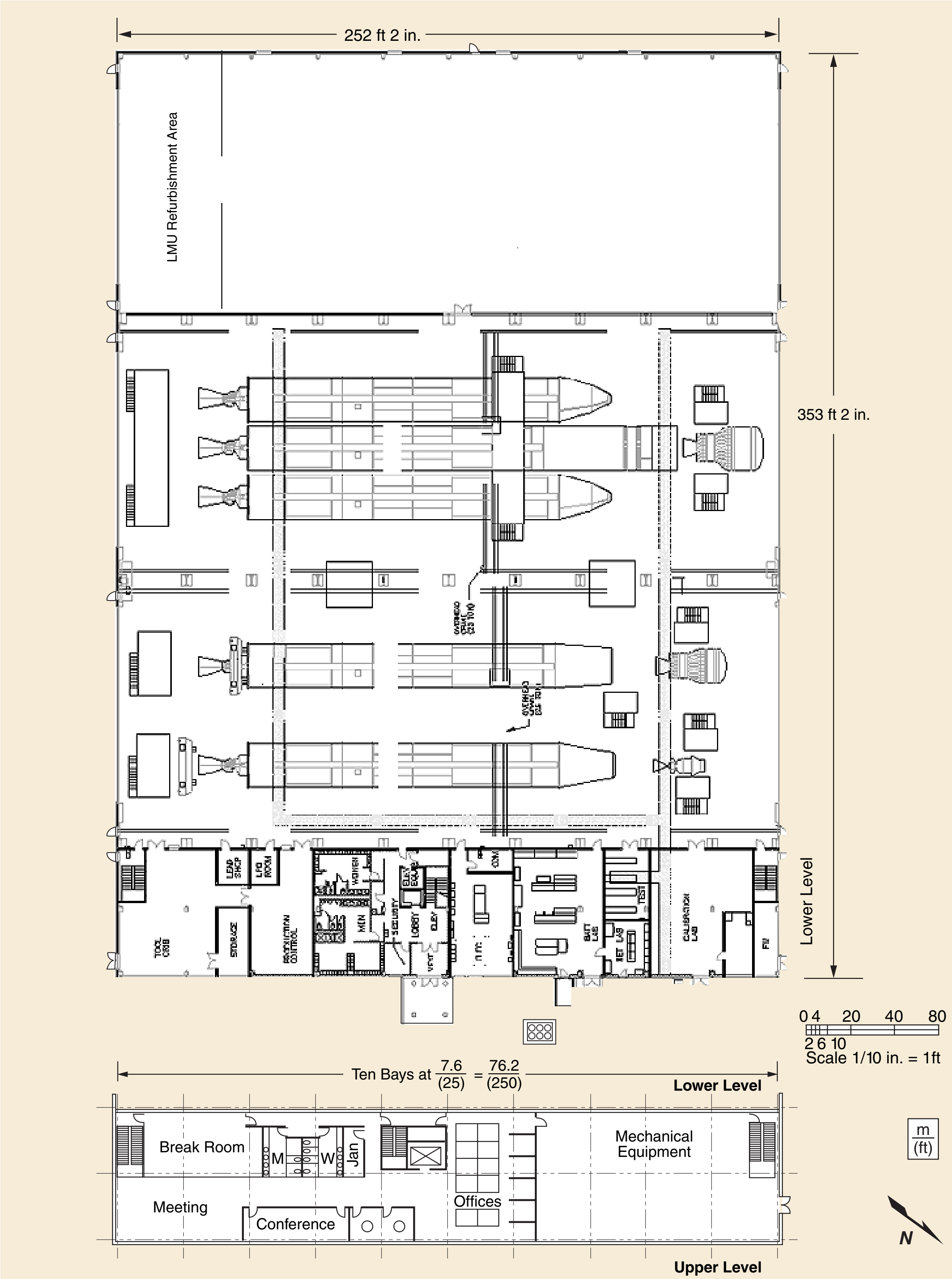


**Figure 6-24. Space Launch Complex 37, Horizontal Integration Facility (HIF)**

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Figure 6-25. Space Launch Complex 37, Horizontal Integration Facility—Aerial View

### 6.4.6 Launch Control

The range operations control center (ROCC) is used to control range safety and other range operations. (No physical modifications are planned for the ROCC [facility 81900] to support the Delta IV program.) The launch control center (LCC) for launch complex 37 is located in the Delta Operations Center (DOC, building 38835) (Figure 6-14).

## 6.5 SUPPORT SERVICES

### 6.5.1 Launch Support

For countdown operations, the launch team is normally located in the DOC, with support from many other organizations. Payload command and control equipment can be located at payload processing facilities or the DOC.

The following paragraphs describe the organizational interfaces and the launch decision process.

**6.5.1.1 Mission Director Center (MDC).** The Mission Director Center, located on the fourth floor of the DOC, provides the necessary seating, data display, and communication to observe the launch process. Seating is provided for key personnel from the spacecraft control team (Figure 6-26).

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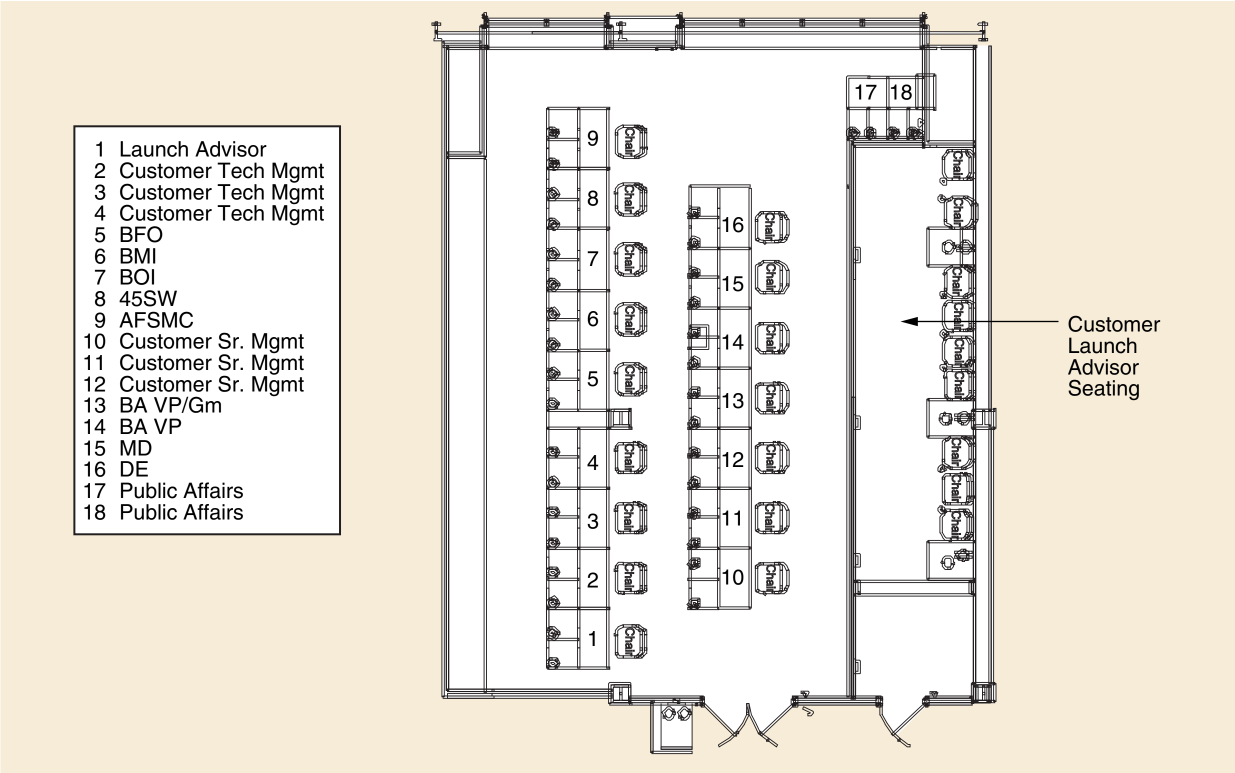


**Figure 6-26. Space Launch Complex 37 Mission Director Center (MDC)**

**6.5.1.2 Launch Decision Process.** The launch decision process is conducted by appropriate management personnel representing the payload, the launch vehicle, and the range. Figure 6-27 shows the typical communication flow required to make the launch decision for Delta IV.

### 6.5.2 Weather Constraints

**6.5.2.1 Ground-Wind Constraints.** Delta IV launch vehicles are enclosed in the MST until approximately launch minus 7 hours (T-7h). The tower protects the launch vehicle from ground winds as measured using the mini-SODAR located at the pad and several anemometers at various locations around the pad.

**6.5.2.2 Winds-Aloft Constraints.** Measurements of winds aloft are taken at the launch pad. On launch day, Delta IV launch vehicle controls and load constraints for winds aloft are evaluated by conducting a trajectory analysis using the measured wind. A curve fit to the wind data provides load relief in the trajectory analysis. The curve fit and other load-relief parameters are used to adjust the mission constants just prior to launch.

**6.5.2.3 Natural/Triggered Lightning Launch Constraints.** Natural/triggered lightning launch constraints are imposed to assure safe passage of the Delta IV launch vehicle

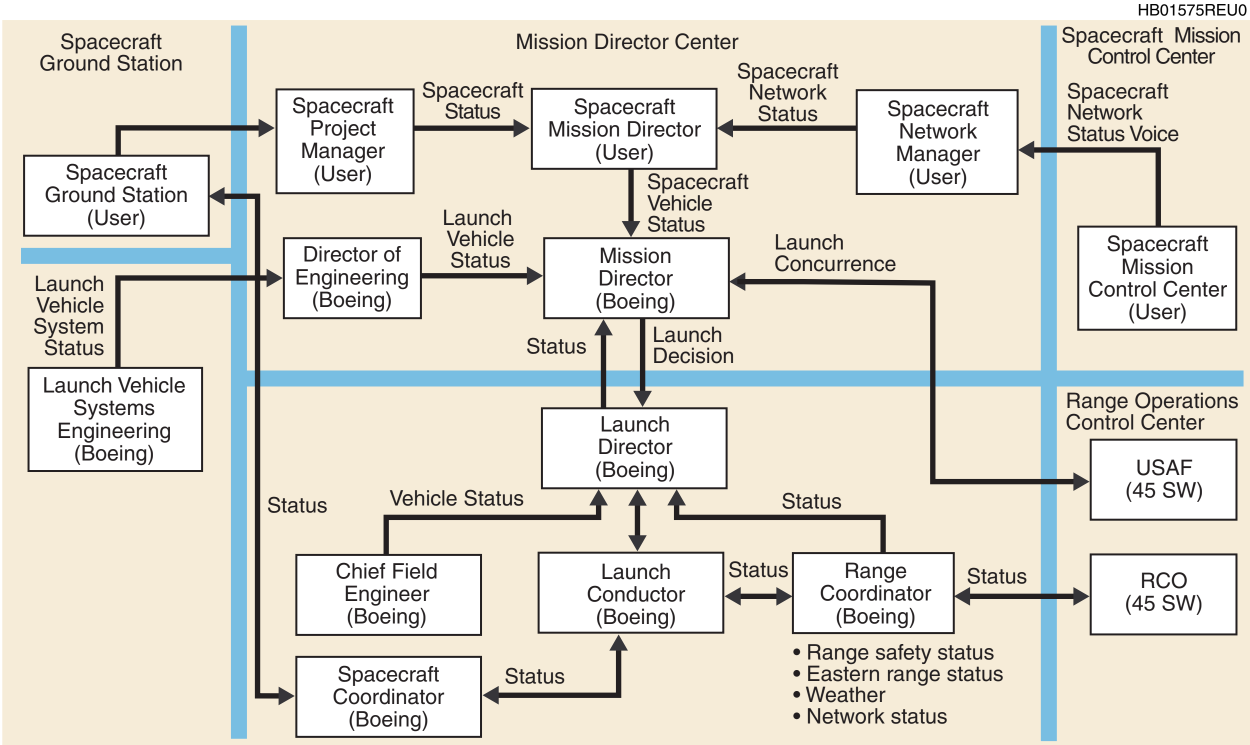


**Figure 6-27. Launch Decision Flow for Commercial Missions–Eastern Range**

through the atmosphere. The following simplified set of constraints (Appendix A contains the complete set) is monitored during the launch countdown sequence. The sequence will be interrupted or canceled if:

1. Any type of lightning is detected within 18.5 km (10 nmi) of the planned flight path within 30 min prior to launch

2. The planned flight path will carry the launch vehicle through or near thunderstorm clouds that are determined to have the potential to produce lightning that will strike the launch vehicle.

3. At any time during the 15 min prior to launch time, the electric field measured at the ground is greater than 1000 V/m within 9.25 km (5 nmi) of the flight path except when there are no clouds with potential of causing lightning and a benign source of electric field was determined as being the cause of the elevated reading.

4. The flight path is through a vertically continuous layer of clouds with an overall depth of 1372 m (4,500 ft) or greater where any part of the clouds is located between 0°C and –20°C levels.

5. The flight path is through clouds that are at or above 0°C and are associated with weather-producing precipitation within 9.25 km (5 nmi) of the flight path.

6. The flight path will carry the launch vehicle through nontransparent thunderstorm clouds during the first 3 hr after the debris cloud is formed from the parent cloud.

7. The flight path will carry the launch vehicle within 9.25 km (5 nmi) of nontransparent thunderstorm clouds during the first 3 hr after the debris cloud is formed from the parent cloud, unless the electric field measured on the ground and the radar reflectivity from the entire debris cloud are benign.

Even though the above criteria are observed or forecasted to have been satisfied at the predicted launch time, the launch director may elect to delay the launch based on the instability of atmospheric conditions.

### 6.5.3 Operational Safety

Safety requirements are covered in Section 9 of this document. In addition, it is the operating policy at both CCAFS and Astrotech that all personnel be given safety orientation briefings prior to entrance to hazardous areas. These briefings are scheduled by the Boeing spacecraft coordinator and presented by appropriate safety personnel.

### 6.5.4 Security

**6.5.4.1 CCAFS Security.** To gain access to CCAFS, U.S. citizens must provide visit notification to the Boeing Delta IV Security Office. This notification must contain full name (last, first, middle), social security number, company affiliation and address, purpose of visit, and dates of visit (beginning and ending) at least 7 days prior to the expected arrival date. The Boeing Delta IV Security Office will arrange for the appropriate badging credentials for entry to CCAFS for commercial missions or individuals sponsored by Boeing Delta IV. Access by NASA personnel or NASA-sponsored foreign nationals will be coordinated through the appropriate NASA Center and the Boeing Delta IV Security Office. Foreign nationals and U.S. citizens affiliated with non-U.S. firms, or U.S. firms with foreign contracts, must follow the appropriate accreditation process. Delta Launch Services will, in turn, advise the Delta IV Launch Site Mission Integration and Security Office of those individuals who are approved for access to the Delta IV Launch Site. Delta IV Security will coordinate the foreign national visitor(s) visit notification to obtain badging for CCAFS. All foreign national visits to CCAFS are approved by the 45th Space Wing Foreign Disclosure Manager. The following foreign national information must be submitted to the Delta IV Security Office to obtain appropriate badging approval:

1. Full Name (last, first, middle)
2. Date/place of birth
3. Home address
4. Organizational affiliation and address
5. Citizenship
6. Passport number

7. Passport date/place of issue
8. Visa number and date of expiration
9. Job title/description
10. Dates of visit
11. Purpose of visit (mission name)

This information must be provided to the Delta IV Security Office 60 days prior to the CCAFS entry date.

**6.5.4.2 Launch Complex Security.** SLC-37 is surrounded by perimeter fencing with an intrusion detection system and alarms. Closed-circuit television (CCTV) is used for immediate visual assessment (IVA) of the fence line. The SLC is protected by an electronic security system (ESS) that consists of personnel entry/exit accountability using electronic proximity card readers, intrusion door alarms on MST levels 8 through 14, and payload user rooms located on MST level 8 and in the support equipment building (SEB). Security guards will be posted at the SLC-37 security entry control building (SECB) 5 days per week, 16 hours per day, or as operationally required to support launch preparation activities. For badging purposes, arrangements must be made through the Boeing Delta IV Security Office at least 30 days prior to the intended arrival date at the SLC.

**6.5.4.3 Astrotech Security.** Physical security at Astrotech facilities is provided by chain-link perimeter fencing, door locks, and guards. Details of payload security requirements will be arranged through the Boeing spacecraft coordinator.

### 6.5.5 Field-Related Services

Boeing employs certified handlers wearing propellant handler's ensemble (PHE) suits, equipment drivers, welders, riggers, and explosive ordnance handlers in addition to personnel experienced in most electrical and mechanical assembly skills such as torquing, soldering, crimping, precision cleaning, and contamination control. Boeing has access to a machine shop, metrology laboratory, $LO_2$ cleaning facility, proof-load facility, and hydrostatic proof test equipment. Boeing operational team members are familiar with the payload processing facilities and can offer all these skills and services to the spacecraft contractor during the launch program.

## 6.6 DELTA IV PLANS AND SCHEDULES

### 6.6.1 Mission Plan

At least 12 months prior to each launch campaign, a mission launch operations schedule is developed that shows major tasks in a weekly timeline format. The plan includes launch vehicle activities, prelaunch reviews, and payload processing facility (PPF) and horizontal integration facility (HIF) occupancy time.

### 6.6.2 Integrated Schedules

The schedule of payload activities occurring before integrated activities in the HIF varies from mission to mission. The extent of payload field testing varies and is determined by the customer.

Payload/launch vehicle schedules are similar from mission to mission, from the time of payload weighing until launch.

Daily schedules are prepared on hourly timelines for these integrated activities. These daily schedules typically cover the encapsulation effort in the PPF and all day-of-launch countdown activities. Tasks include payload weighing, spacecraft-to-PAF mate, encapsulation, and interface verification. Figures 6-28, 6-29, 6-30, 6-31, 6-32, 6-33 and 6-34 show the integrated processing timelines for the

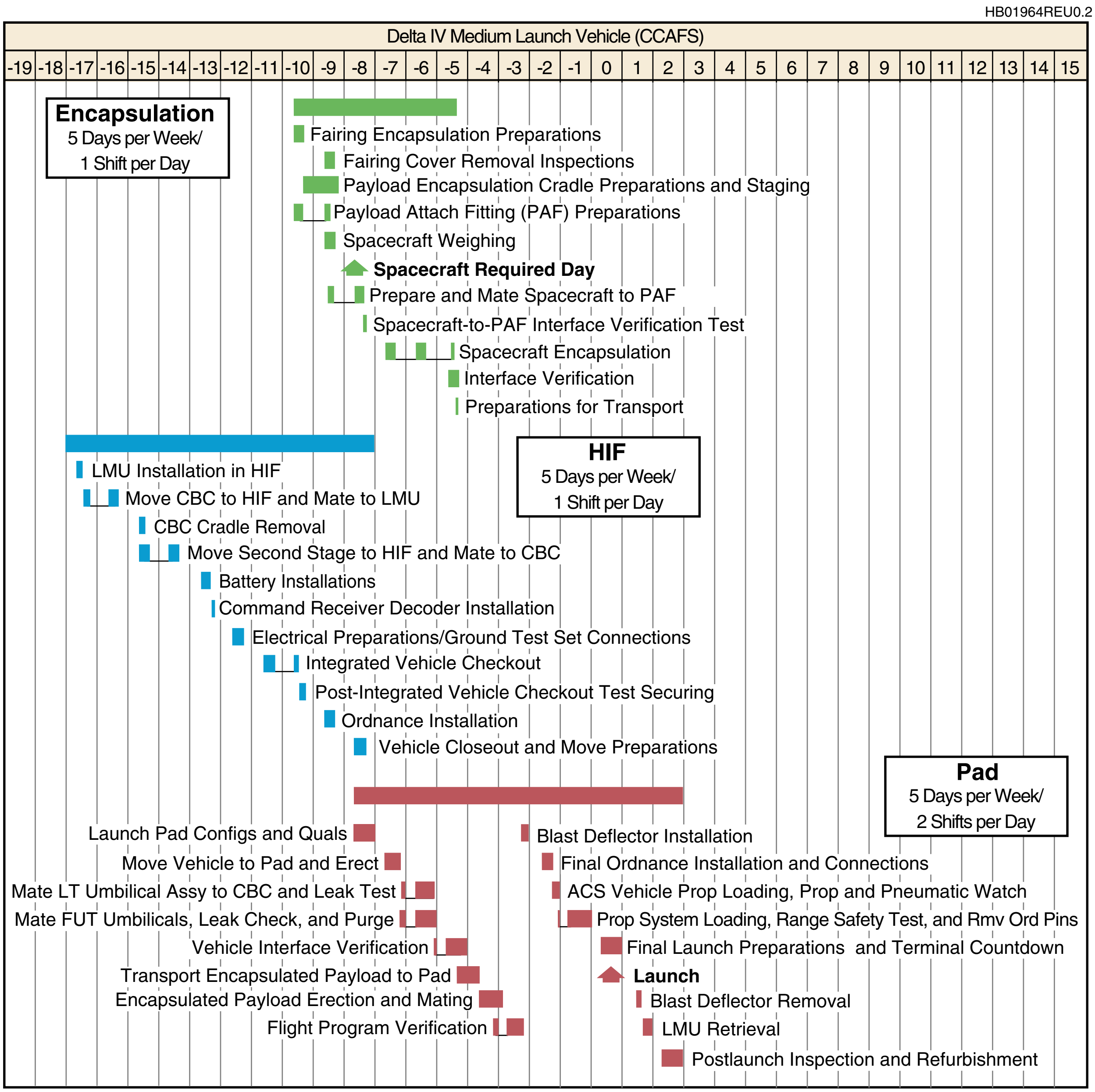


**Figure 6-28. Projected Processing Timeline—Delta IV Medium Launch Vehicle (rev. L)**

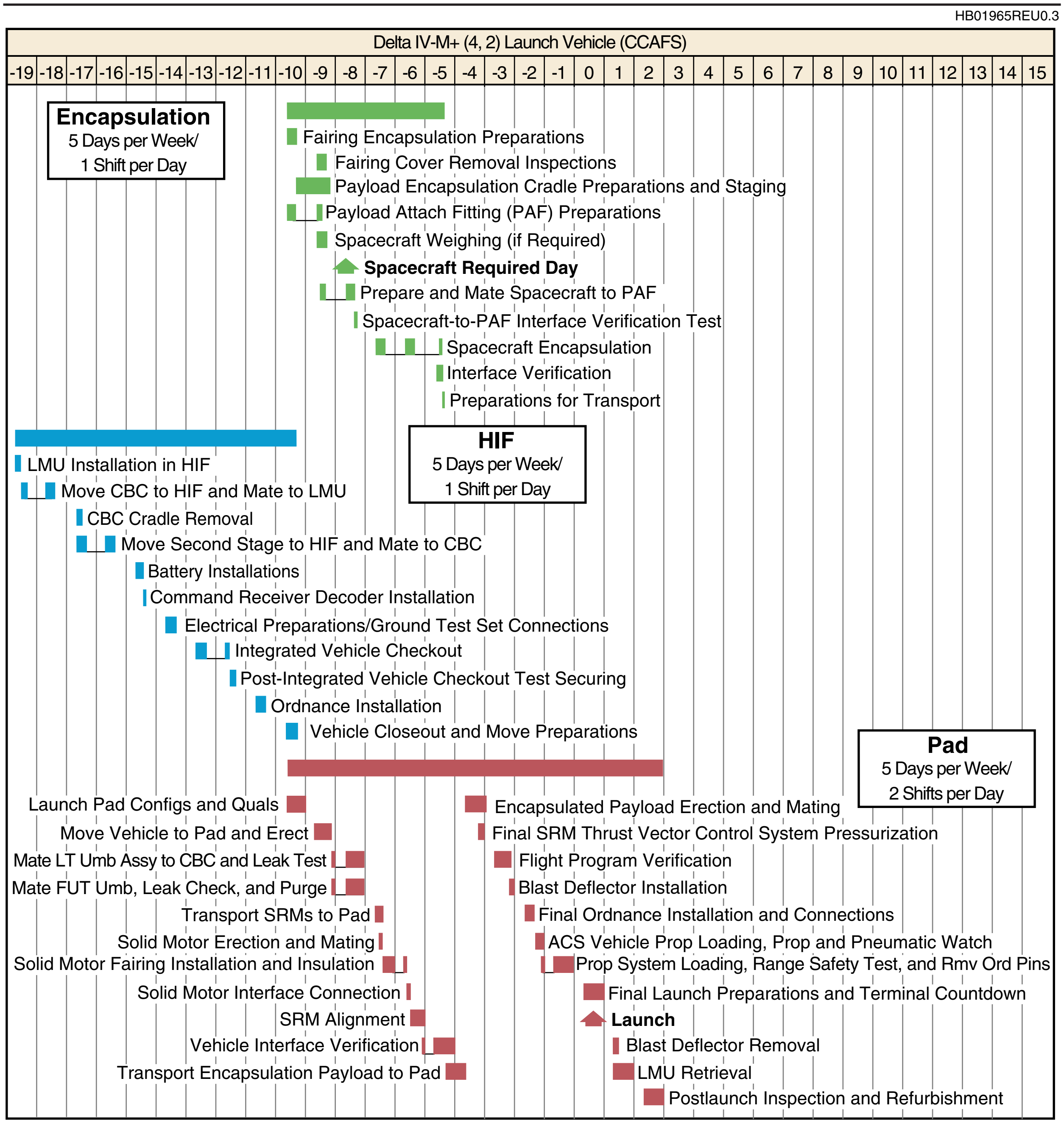


**Figure 6-29. Projected Processing Timeline—Delta IV Medium-Plus (4,2) Launch Vehicle (rev. L)**

Delta IV-M, Delta IV-M+ (4,2), Delta IV-M+ (5,2), Delta IV-M+ (5,4), Delta IV-H composite fairing, Delta IV-H metallic fairing, and Delta IV-H dual-manifest, respectively. The countdown schedules provide a detailed, day-to-day, hour-by-hour breakdown of launch pad operations, illustrating the flow of activities from spacecraft erection through terminal countdown and reflecting inputs from the spacecraft contractor.

The integrated processing timelines do not normally include Saturdays, Sundays, or holidays. The schedules, from spacecraft mate through launch, are coordinated with each customer to

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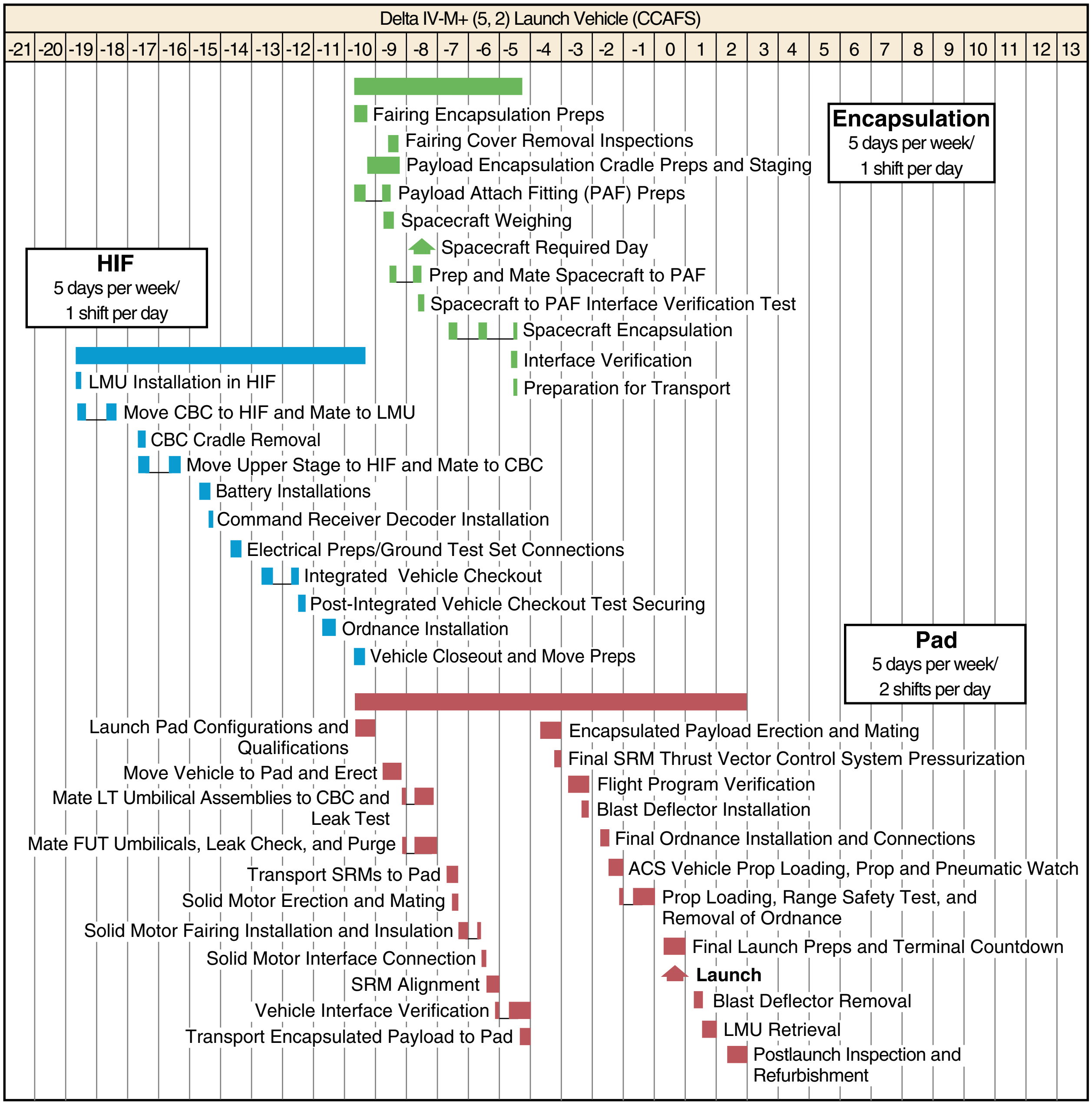


**Figure 6-30. Projected Processing Timeline—Delta IV Medium-Plus (5,2) Launch Vehicle (rev. M)**

optimize on-pad testing. All operations are formally conducted and controlled using approved procedures. The schedule of payload activities during that time is controlled by the Boeing launch operations manager.

### 6.6.3 Launch Vehicle Schedules

One set of facility-oriented 3-week schedules is developed, on a daily timeline, to show processing of multiple launch vehicles through each facility; i.e., for the launch pad, HIF, and PPFs as required. These schedules are revised daily and reviewed at regularly scheduled Delta status

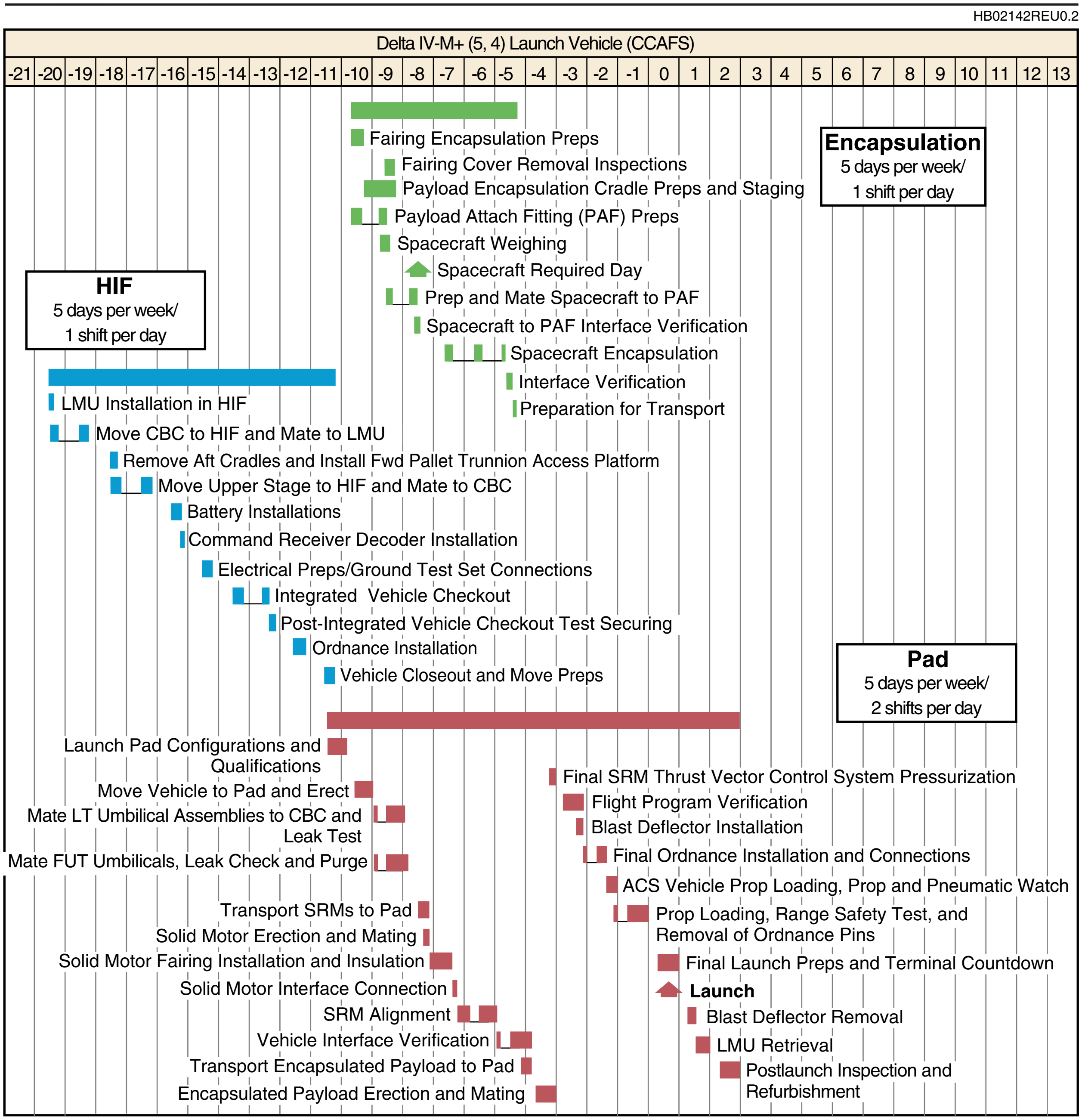


**Figure 6-31. Projected Processing Timeline—Delta IV Medium-Plus (5,4) Launch Vehicle (rev. M)**

meetings. Another set of daily timeline launch-vehicle-specific schedules is generated covering a period that shows the complete processing of each launch vehicle component. Individual schedules are made for the HIF, PPF, and launch pad.

### 6.6.4 Spacecraft Schedules

The spacecraft project team will supply schedules to the appropriate agency for flowdown to the Boeing spacecraft coordinator, who will arrange support as required.

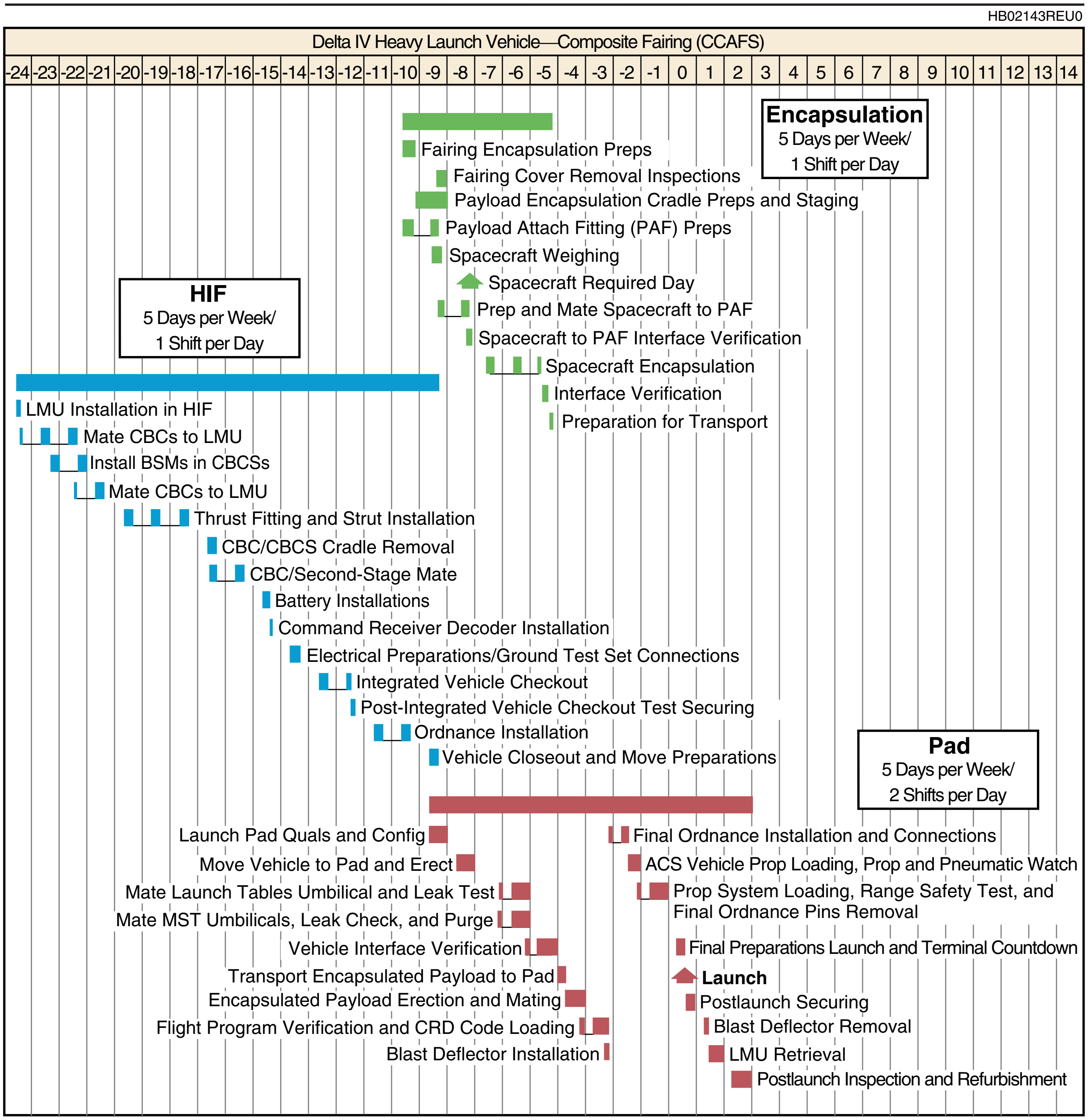


**Figure 6-32. Projected Processing Timeline—Delta IV Heavy Launch Vehicle Composite Fairing (rev. L1)**

## 6.7 DELTA IV MEETINGS AND REVIEWS

During launch preparation, meetings and reviews are scheduled as required to assure mission success. Some of these will require spacecraft customer input while others allow the customer to monitor the progress of the overall mission. The Boeing mission integration manager will ensure adequate customer participation.

### 6.7.1 Meetings

Delta status meetings are generally held twice a week. These meetings include a review of the activities scheduled and accomplished since the last meeting, a discussion of problems and

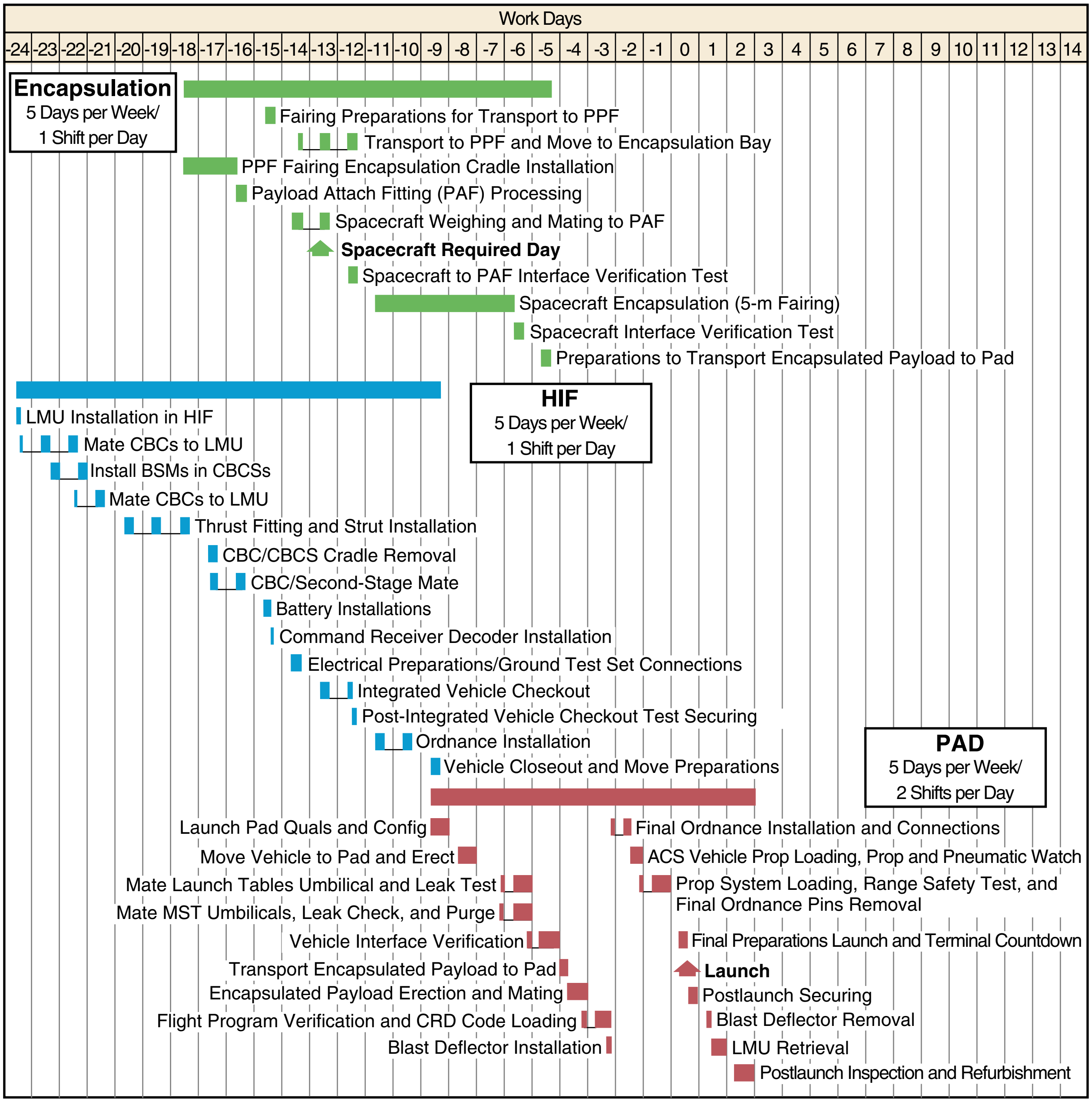


**Figure 6-33. Projected Processing Timeline—Delta IV Heavy Launch Vehicle Metallic Fairing (rev. M)**

their solutions, and a general review of the mission schedule and specific mission schedules. Customers are encouraged to attend these meetings.

Daily schedule meetings provide the team members with their assignments and summaries of the previous or current day's accomplishments. These meetings are attended by the launch conductor, technicians, inspectors, engineers, supervisors, and the spacecraft coordinator. Depending on testing activities, these meetings are held at the beginning of the first shift.

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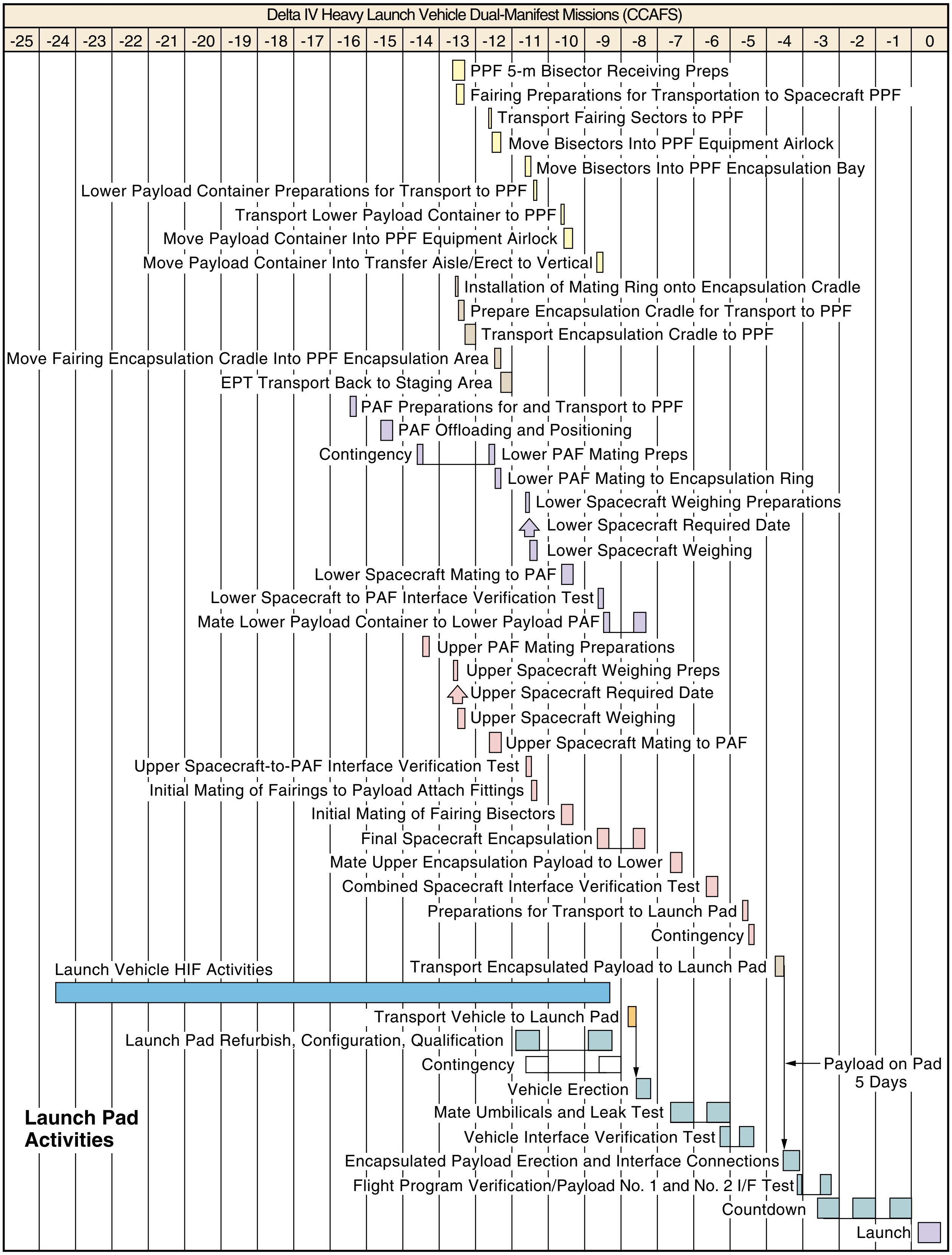


**Figure 6-34. Projected Processing Timeline for Delta IV Heavy Launch Vehicle Dual-Manifest Missions (Preliminary)**

### 6.7.2 Prelaunch Review Process

Periodic reviews are held to ensure that the payload and launch vehicle are ready for launch. The mission plan will show the relationship of the reviews to the program assembly and test flow.

The following paragraphs describe Delta IV readiness reviews.

**6.7.2.1 Postproduction Review.** At this meeting, conducted at Decatur, Alabama, flight hardware that is at the end of production and ready for shipment to CCAFS is reviewed.

**6.7.2.2 Mission Analysis Review.** This meeting is held at Huntington Beach, California, approximately 3 months prior to launch to review mission-specific drawings, studies, and analyses.

**6.7.2.3 Pre-Vehicle-On-Stand Review.** A prevehicle-on-stand (pre-VOS) review is held at CCAFS subsequent to completion of HIF processing and prior to erection of the vehicle on the launch pad. It includes an update of the activities since manufacturing, the results of HIF processing, and hardware history changes. Launch facility readiness is also discussed. (The pre-VOS review occurs approximately at T-12.)

**6.7.2.4 Flight Readiness Review.** The flight readiness review (FRR) defines the status of the launch vehicle after HIF processing and a mission analysis update. It is conducted to determine that the launch vehicle and payload are ready for countdown and launch. Upon completion of this review, authorization is given to proceed with the final phases of countdown preparation. This review also assesses the readiness of the range to support launch and provides predicted weather data. (FRR occurs at T-2 days.)

**6.7.2.5 Launch Readiness Review.** The launch readiness review (LRR) is held on T-1 day. All agencies and contractors are required to provide a ready-to-launch statement. Upon completion of this meeting, authorization to enter terminal countdown is given.

# Section 7
# LAUNCH OPERATIONS AT WESTERN RANGE

This section presents a description of Delta launch vehicle operations associated with Space Launch Complex 6 (SLC-6) at Vandenberg Air Force Base (VAFB), California. Prelaunch processing of the Delta IV launch system is discussed, as are payload processing and operations conducted prior to launch day.

## 7.1 ORGANIZATIONS

As operator of the Delta IV launch system, The Boeing Company maintains an operations team at VAFB that provides launch services to the United States Air Force (USAF), National Aeronautics and Space Administration (NASA), and commercial customers. Boeing provides the interface to the Federal Aviation Administration (FAA) and Department of Transportation (DOT) for licensing and certification to launch commercial payloads using the Delta IV family of launch vehicles.

Boeing has established an interface with the USAF 30th Space Wing Directorate of Plans; the Western Range has designated a range program support manager (PSM) to represent the 30th Space Wing. The PSM serves as the official interface for all launch support and services requested. These services include range instrumentation, facilities/equipment operation and maintenance, safety, security, and logistics support. Requirements for range services are described in documents prepared and submitted to the government by Boeing, based on inputs from the customer, using the government's universal documentation system (UDS) format (see Section 8, Payload Integration). Boeing and the customer generate the program requirements document (PRD). Formal submittal of these documents to the government agencies is arranged by Boeing.

For commercial customer launches, Boeing makes all the arrangements for the payload processing facilities (PPF) and services. The organizations that support a launch from VAFB are listed in Figure 7-1. For each mission, a spacecraft coordinator from the Boeing VAFB launch team is assigned to assist the spacecraft team during the launch campaign by helping to obtain safety approval of the payload test procedures and operations; integrating the spacecraft operations into the launch vehicle activities; and, during the countdown and launch, serving as the interface between the payload and test conductor in the launch control center (LCC). Boeing interfaces with NASA at VAFB through the VAFB Kennedy Space Center (KSC) resident office.

## 7.2 FACILITIES

In addition to facilities required for Delta IV launch vehicle processing, specialized PPFs are provided for checkout and preparation of the payload. Laboratories, cleanrooms, receiving and shipping areas, hazardous operations areas, and offices are provided for payload project personnel.

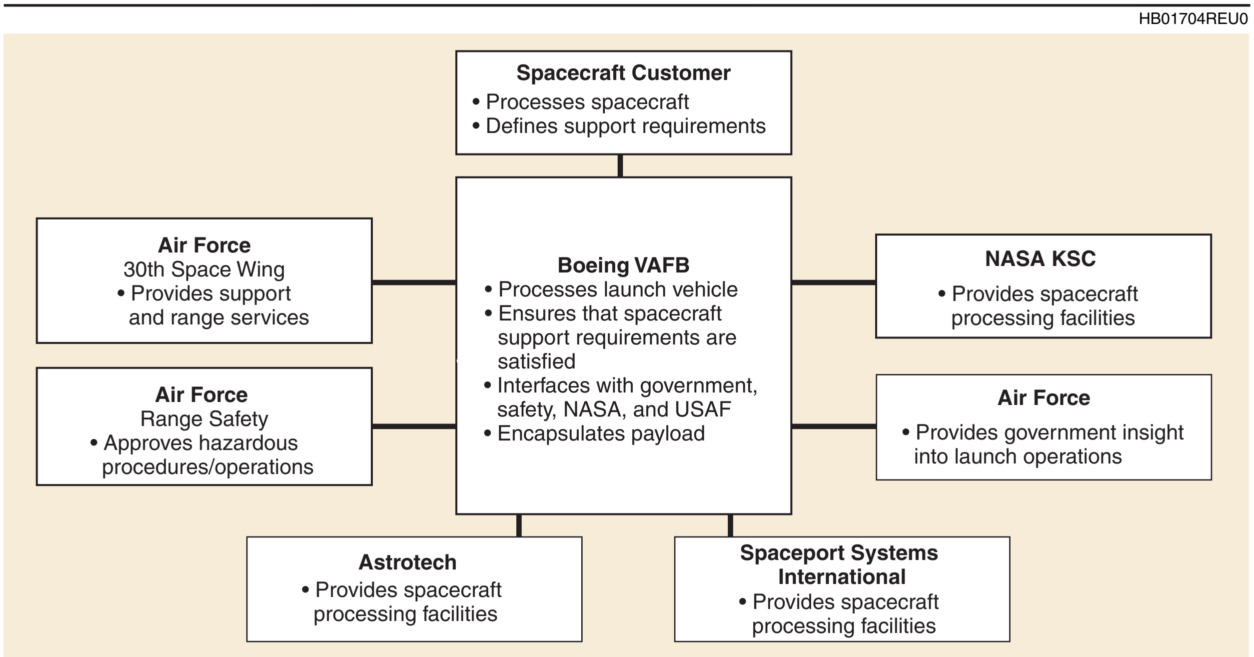


**Figure 7-1. Launch Base Organization at VAFB for Commercial Launches**

As discussed in Section 6.2, offline encapsulation of fueled payloads is a key element of the Delta IV program. The Boeing study conducted for existing encapsulation facilities revealed that government-owned or -operated PPFs at VAFB are capable of supporting limited Delta IV encapsulation operations. The study revealed that only the Astrotech Space Operations (ASO) facilities are capable of fully supporting Delta IV 4-m fairings without modifications. The study also showed that, with some modifications, the integrated processing facility (IPF) operated by Spaceport Systems International (SSI), near Space Launch Complex 6 (SLC-6), can accommodate the Delta IV 4-m and 5-m fairings. Details of this study are discussed in Section 7.3.1.

A map of VAFB (Figure 7-2), shows the location of all major facilities and space launch complexes.

The commonly used facilities at the western launch site for NASA or commercial payloads are the following:

A. Payload processing facilities (PPF):
   1. NASA-provided facility: building 836.
   2. Astrotech Space Operations: building 1032.
   3. Spaceport Systems International building 375.
B. Hazardous processing facilities (HPF):
   1. NASA-provided facility: building 1610.
   2. Astrotech Space Operations: building 1032.
   3. Spaceport Systems International: building 375.

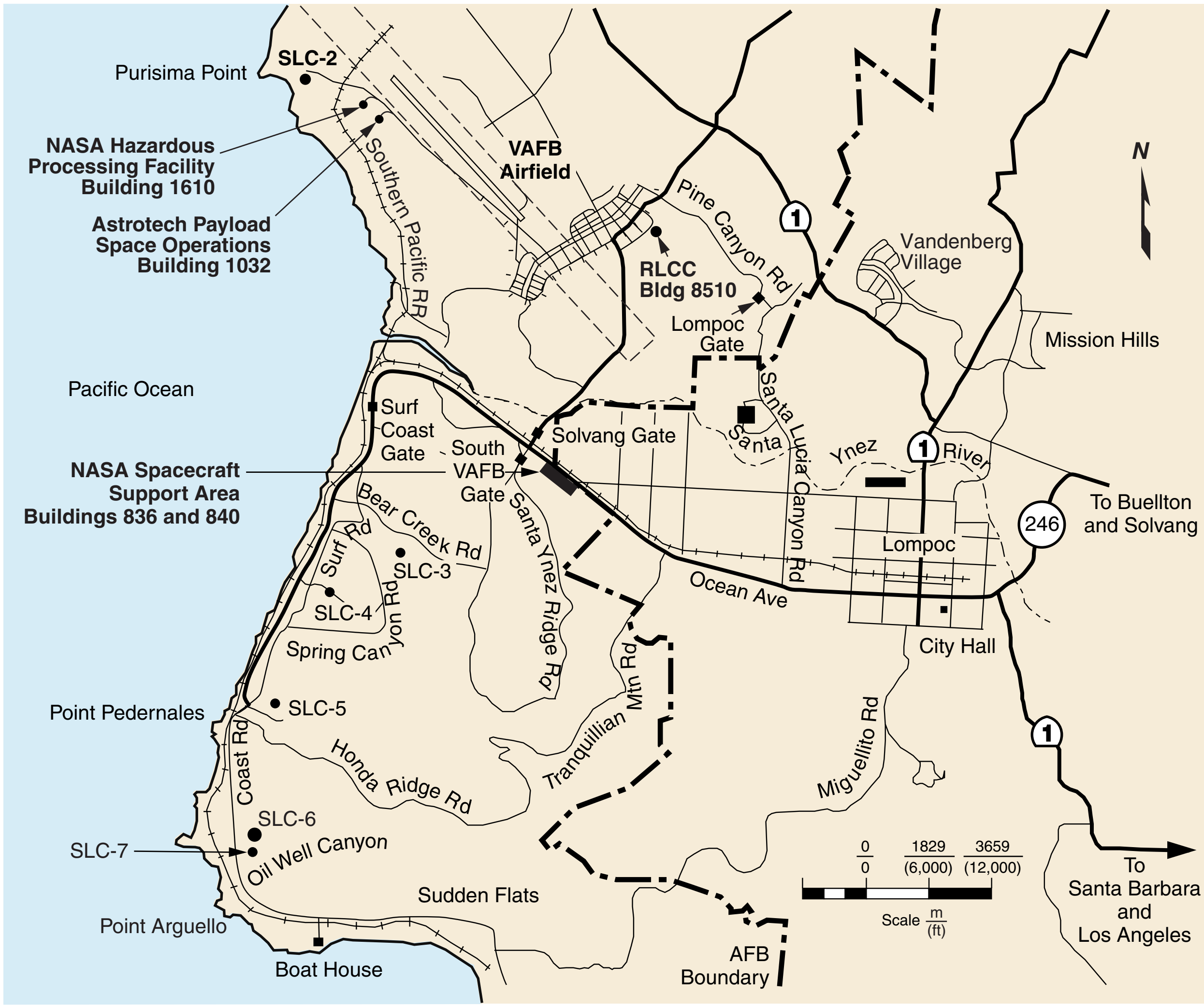


**Figure 7-2. Vandenberg Air Force Base (VAFB) Facilities**

While there are other spacecraft processing facilities located on VAFB that are under USAF control, commercial spacecraft will normally be processed through the commercial facilities of ASO or SSI. Government facilities for spacecraft processing (USAF or NASA) can be used for commercial spacecraft only under special circumstances (use requires negotiations between Boeing, the customer, and USAF or NASA). For spacecraft preparations, the customer must provide its own test equipment including telemetry receivers and telemetry ground stations.

After arrival of the payload and its associated equipment at VAFB by road or by air (via the VAFB airfield), transportation of the spacecraft and associated equipment to the spacecraft processing facility is a service provided by the customer-selected processing facility with assistance from Boeing. Equipment and personnel are also available for loading and unloading operations. It should be noted that the size of the shipping containers often dictates the type of aircraft used for transportation to the launch site. The carrier should be consulted for the type of freight unloading equipment that will be required at the Western Range. Shipping containers and handling fixtures attached to the payload are provided by the customer.

Shipping and handling of hazardous materials, such as electro-explosive devices (EEDs) or radioactive sources, must be in accordance with applicable regulations. It is the responsibility of the customer to identify these items and to become familiar with such regulations. Included are regulations imposed by NASA, USAF, and FAA (refer to Section 9).

### 7.2.1 NASA Facilities on South VAFB

NASA spacecraft facilities are located in the NASA support area on South VAFB (Figure 7-3). The spacecraft support area is adjacent to Ocean Avenue on Clark Street and is accessible through the SVAFB South Gate. The support area consists of the spacecraft laboratory (building 836), NASA technical shops, NASA supply, and NASA engineering and operations building (building 840).

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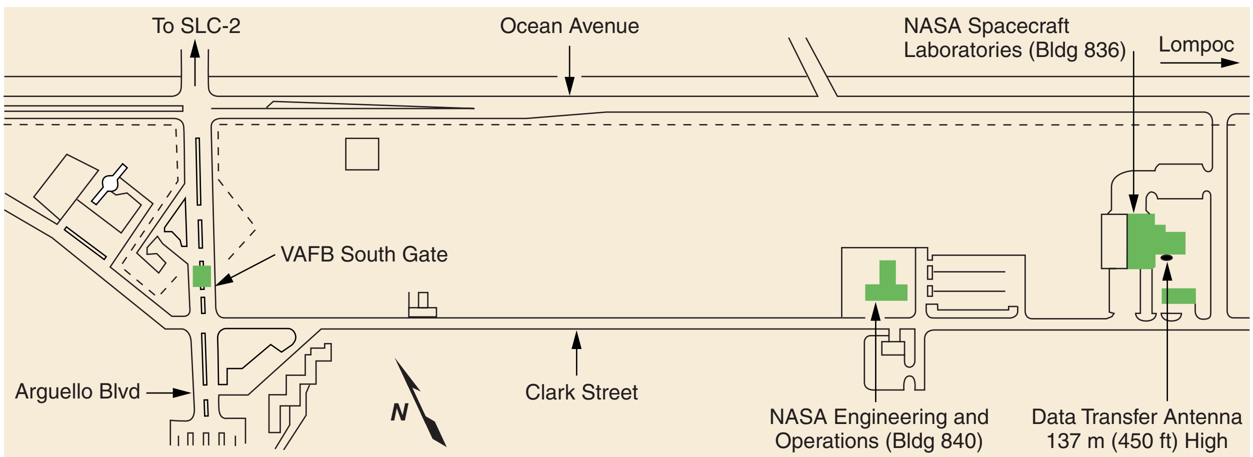


**Figure 7-3. Spacecraft Support Area**

**7.2.1.1 NASA Telemetry Station and Spacecraft Laboratories.** The NASA telemetry station and spacecraft laboratories, building 836 (Figures 7-4 and 7-5), are divided into work and laboratory areas and include spacecraft assembly areas, laboratory areas, cleanrooms, computer facility, office space, conference room, and the telemetry station.

Spacecraft laboratory 1 (Figure 7-5) consists of a high bay 20.4 m (67 ft) long by 9.8 m (32 ft) wide by 9.1 m (30 ft) high and an adjoining 334-m$^2$ (3600-ft$^2$) support area. Personnel access doors and a sliding door 3.7 m (12 ft) by 3.7 m (12 ft) connect the two portions of this laboratory. The outside cargo entrance door to the spacecraft assembly room in laboratory 1 is 6.1 m (20 ft) wide by 7.8 m (25 ft, 7 in.) high. A bridge crane, with an 8.8-m (29-ft) hook height and a 4545-kg (5-ton) capacity, is available for handling spacecraft and associated equipment. This assembly room contains a class 10,000 horizontal laminar flow cleanroom, 10.4 m (34 ft) long by 6.6 m (21.5 ft) wide by 7.6 m (25 ft) high. The front of the cleanroom opens for free entry of the spacecraft and handling

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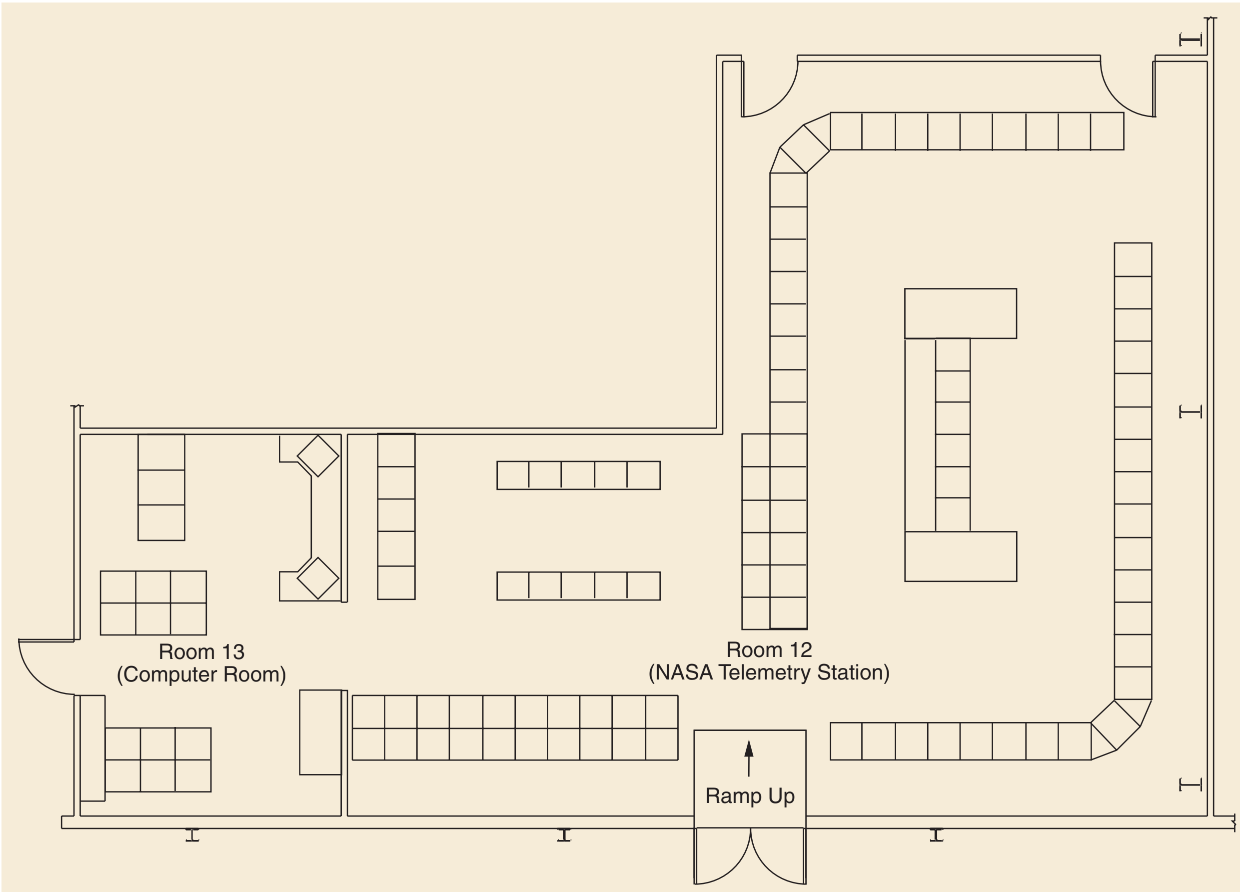


**Figure 7-4. Telemetry Station (Building 836)**

equipment. The cleanroom has crane access in the front-to-rear direction only; however, the crane cannot operate over the entire length of the laboratory without disassembly because its path is obstructed by the horizontal beam that serves as the cleanroom divider. Spacecraft laboratory 1 will also support computer, telemetry, and checkout equipment in a separate room containing raised floors and an under-floor power distribution system. This room has an area of approximately 334 m$^2$ (3600 ft$^2$).

Spacecraft laboratory 2 (Figure 7-6) has a 527 m$^2$ (5670 ft$^2$) work area. A 3.7-m (12-ft) by 5.2-m (17-ft) roll-up door provides access to this area from the high-bay service area. There are three electric overhead cranes available: a fixed 909-kg (1-ton) hoist with a 7-m (23-ft) hook height, and two 909-kg (1-ton) monorail hoists with 5.5-m (18-ft) hook heights. A horizontal laminar flow class 100,000 cleanroom, 9.1 m (30 ft) by 5.2 m (17 ft) by 5.2 m (17 ft) (30 ft by 17 ft by 17 ft), is located in this laboratory for spacecraft use. One end of the cleanroom is open to allow access.

Spacecraft laboratory 3 (Figure 7-7) has an area of 2323 m$^2$ (25,000 ft$^2$). This laboratory is assigned to the NOAA Environmental Monitoring Satellite Program.

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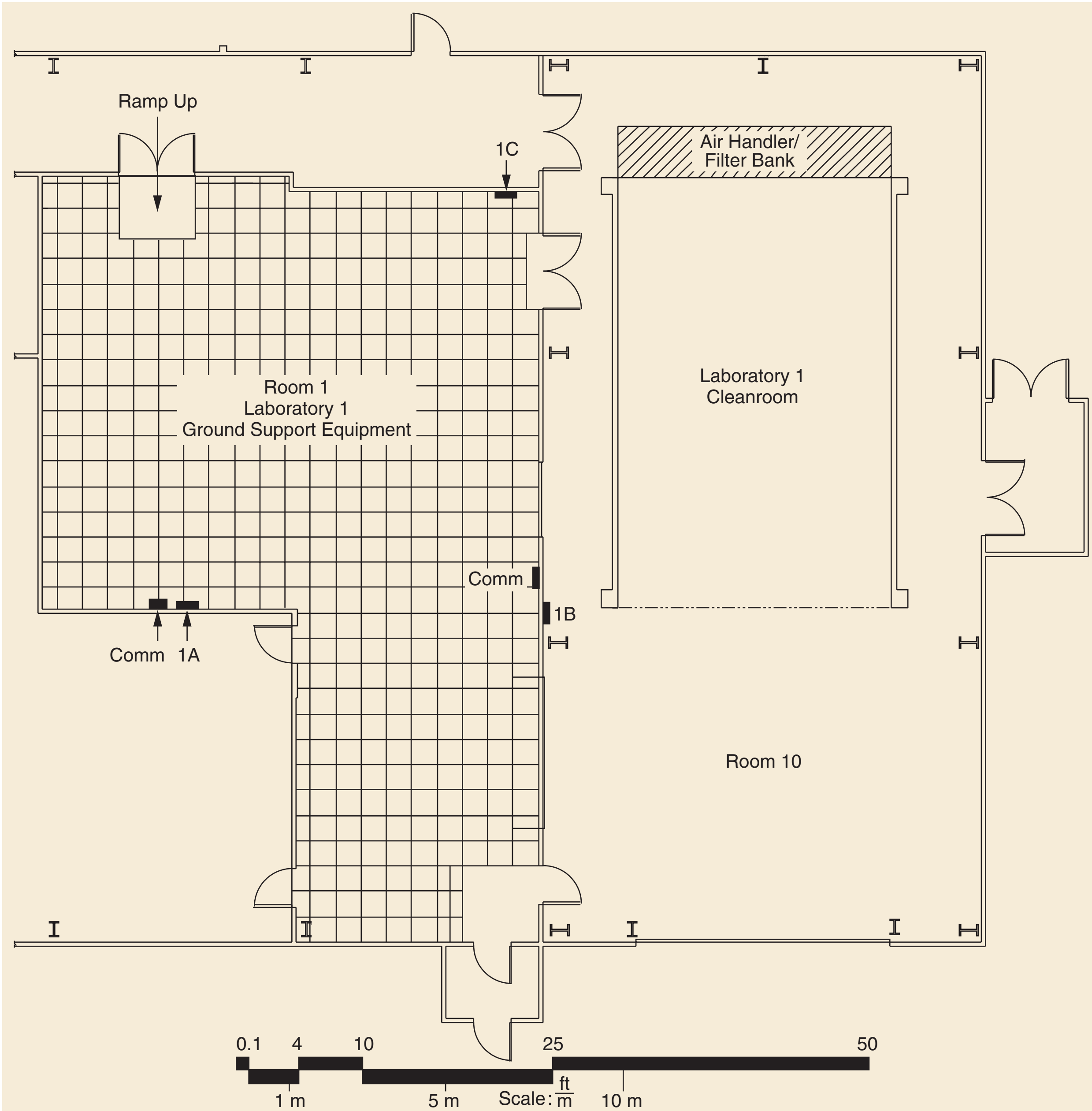


**Figure 7-5. Spacecraft Laboratory 1 (Building 836)**

Launch vehicle data center 1 (LVDC-1) (Figure 7-8) is an area containing 24 consoles for Boeing Delta management and technical support personnel. These positions are manned during countdown and launch to provide technical assistance to the launch team in the remote launch control center (RLCC) and to the Mission Director in the Mission Director Center (MDC) in building 840. These consoles have individually programmed communications panels for specific mission requirements. This provides LVDC personnel with technical communications to monitor and coordinate both prelaunch and launch activities. Video data display terminals in the LVDC are provided for display of range and launch vehicle technical information.

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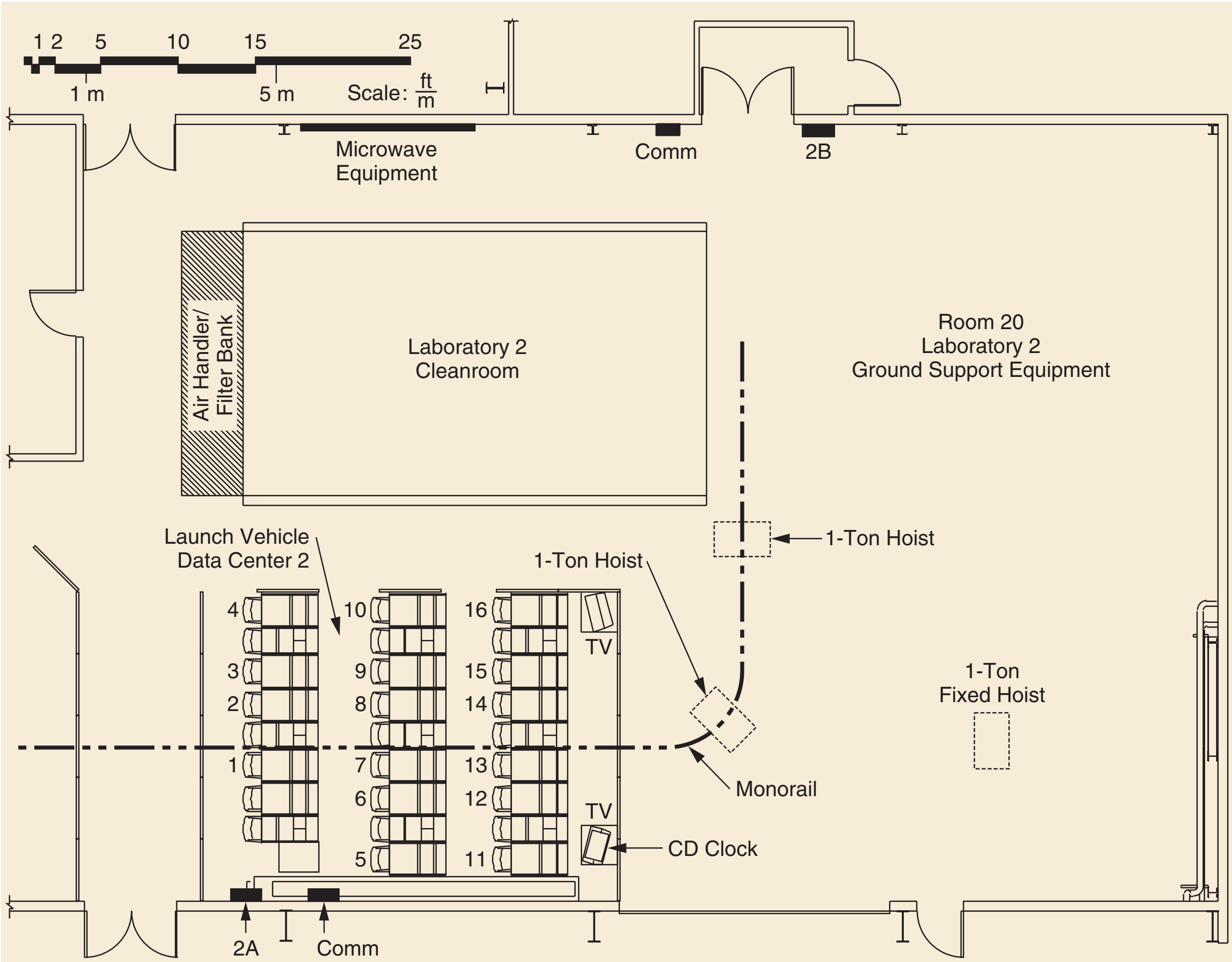


**Figure 7-6. Spacecraft Laboratory 2 (Building 836)**

Launch vehicle data center 2 (LVDC-2), a second data center, is provided with equipment similar to LVDC-1, and may also be used by spacecraft personnel.

The high bay is a 30.5-m (100-ft) by 61-m (200-ft) (100-ft by 200-ft) area serviced by a 22 727-kg (25-ton) crane with a 7.6-m (25-ft) hook height. This area is ideal for handling heavy equipment and loading or unloading trucks. The high bay is heated and has 30.5-m (100-ft) wide by 9.1-m (30-ft) high sliding doors on both ends.

**7.2.1.2 NASA Engineering and Operations Facility.** The NASA engineering and operations facility in building 840 (Figure 7-9) is located on SVAFB at the corner of Clark and Scarpino Streets. It contains the NASA offices, NASA contractor offices, MDC, observation room, conference room, and other office space.

The MDC (Figure 7-10) provides 24 communication consoles for use by the Mission Director, spacecraft and launch vehicle representatives, experimenters, display controller, and communications operators. These consoles have individually programmed communications for specific mission

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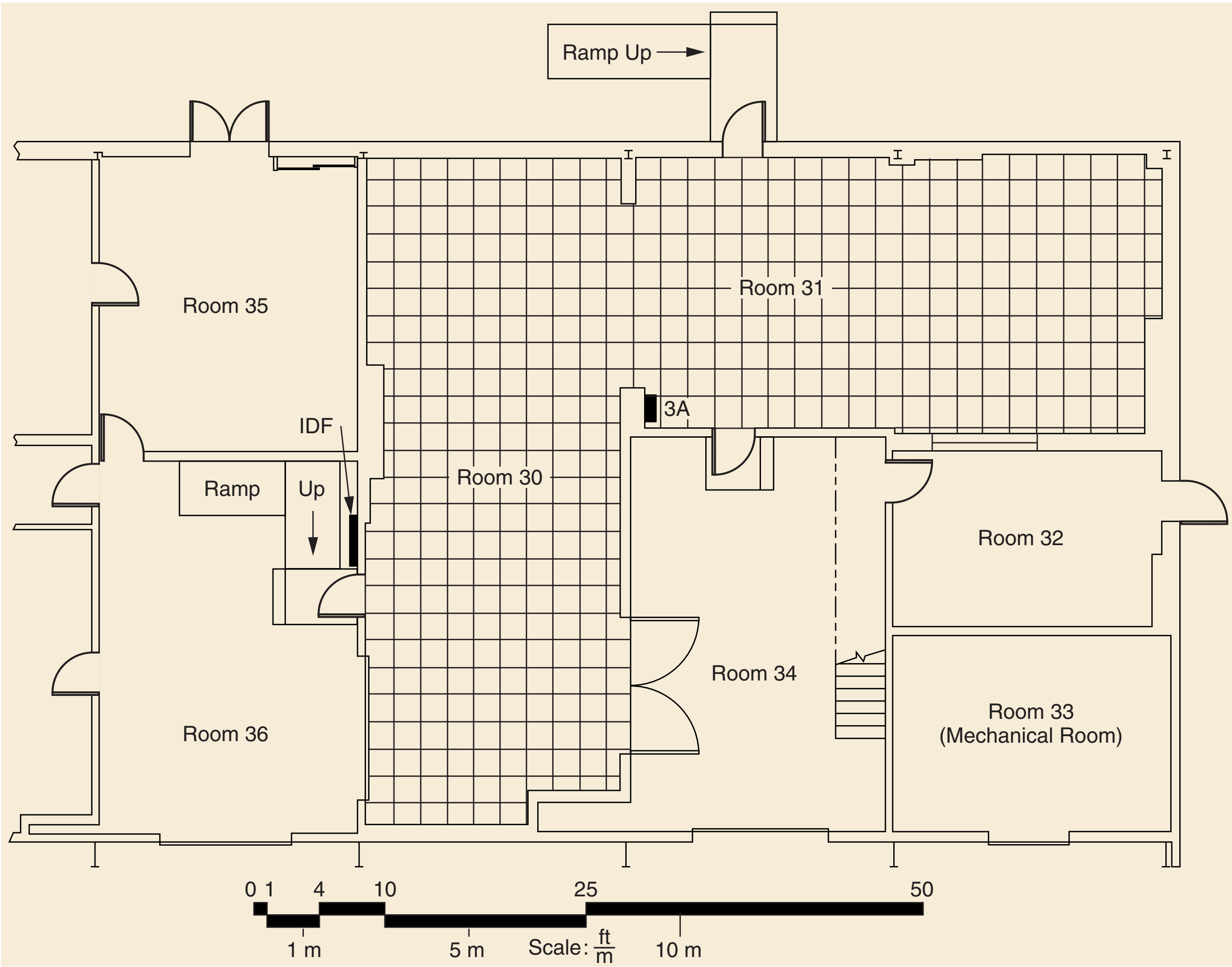


**Figure 7-7. Spacecraft Laboratory 3 (Building 836)**

requirements. This provides Boeing personnel with technical communications to monitor and coordinate both prelaunch and postlaunch activities.

Video data display terminals at the MDC are provided to display range and vehicle technical information. A readiness board and an events display board provide range and launch vehicle/spacecraft status during countdown and launch operations. Many TV display monitors (Figure 7-10) display preselected launch activities.

An observation room, separated from the MDC by a glass partition, is used for authorized visitors. Loudspeakers in the room monitor the communication channels used during the launch.

### 7.2.2 NASA Facilities on North Vandenberg

**7.2.2.1 Hazardous Processing Facility (HPF).** The NASA hazardous processing facility (building 1610) is located approximately 3.2 km (2 mi) east of SLC-2 and adjacent to Tangair Road (Figure 7-11). This facility provides capabilities for the dynamic balancing of spacecraft, solid motors, and combinations thereof. It is also used for fairing processing, solid-motor buildup, spacecraft

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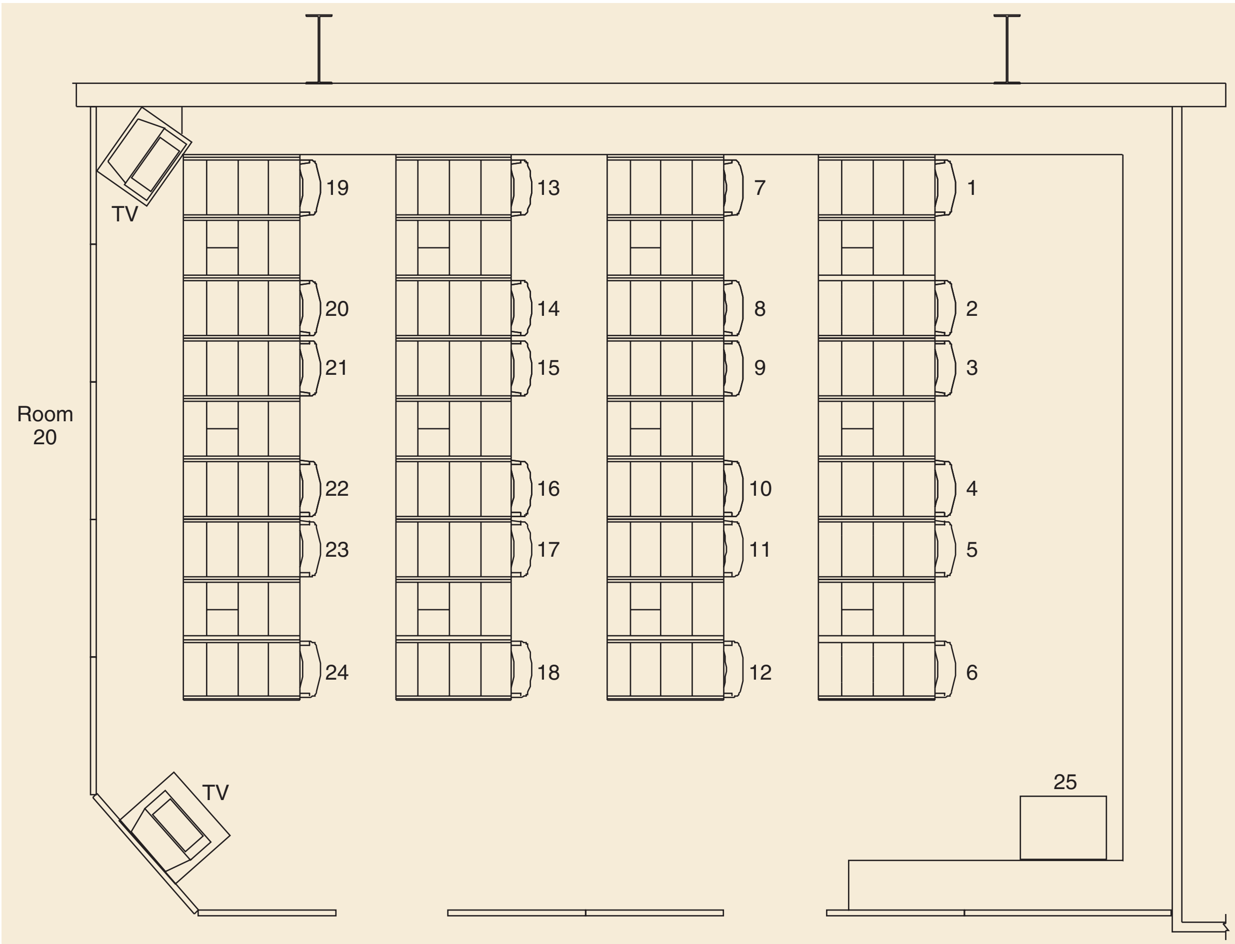


**Figure 7-8. Launch Vehicle Data Center 1 (Building 836)**

buildup, mating of spacecraft and solid motors, ordnance installation, and loading of hazardous propellants. It houses the Schenk treble dynamic balancing machine and equipment for buildup, alignment, and balancing of the second-stage solid-propellant motors and spacecraft. Composite spin balancing of the spacecraft/third-stage combination is not required. The spin-balancing machine is in a pit in the floor of building 1610. The machine interfaces with stages and/or spacecraft at floor level. Facilities consist of the hazardous processing facility (building 1610), control room (building 1605), UPS/generator building (building 1604), guard station, and fire pumping station. Hazardous operations are conducted in building 1610, which is separated from the control room by an earth revetment 4.6 m (15 ft) high. The two buildings are 47.2 m (155 ft) apart.

The HPF (Figure 7-12), is an approved ordnance-handling facility and was constructed for dynamic balancing of spacecraft and solid rocket motors. It is 17.7 m (58 ft) long by 10.4 m (34 ft) wide by 13.7 m (45 ft) high with personnel access doors and a flight equipment entrance door opening that is 5.2 m (17 ft) wide and 9.1 m (29 ft 9 in.) high. The facility is equipped for safe handling of the hydrazine-type propellants used on many space vehicles for attitude control and supplemental

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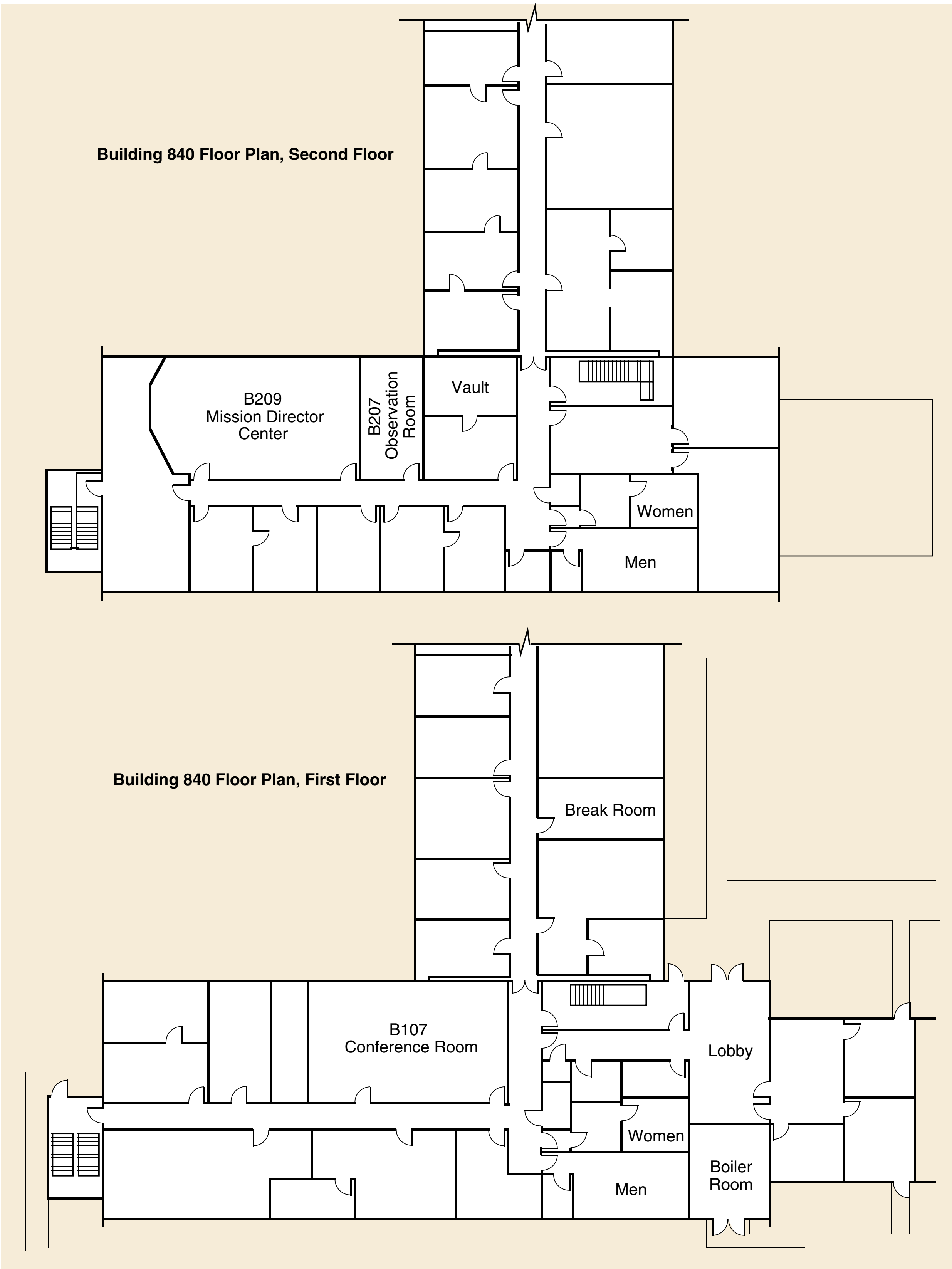


**Figure 7-9. NASA Building 840**

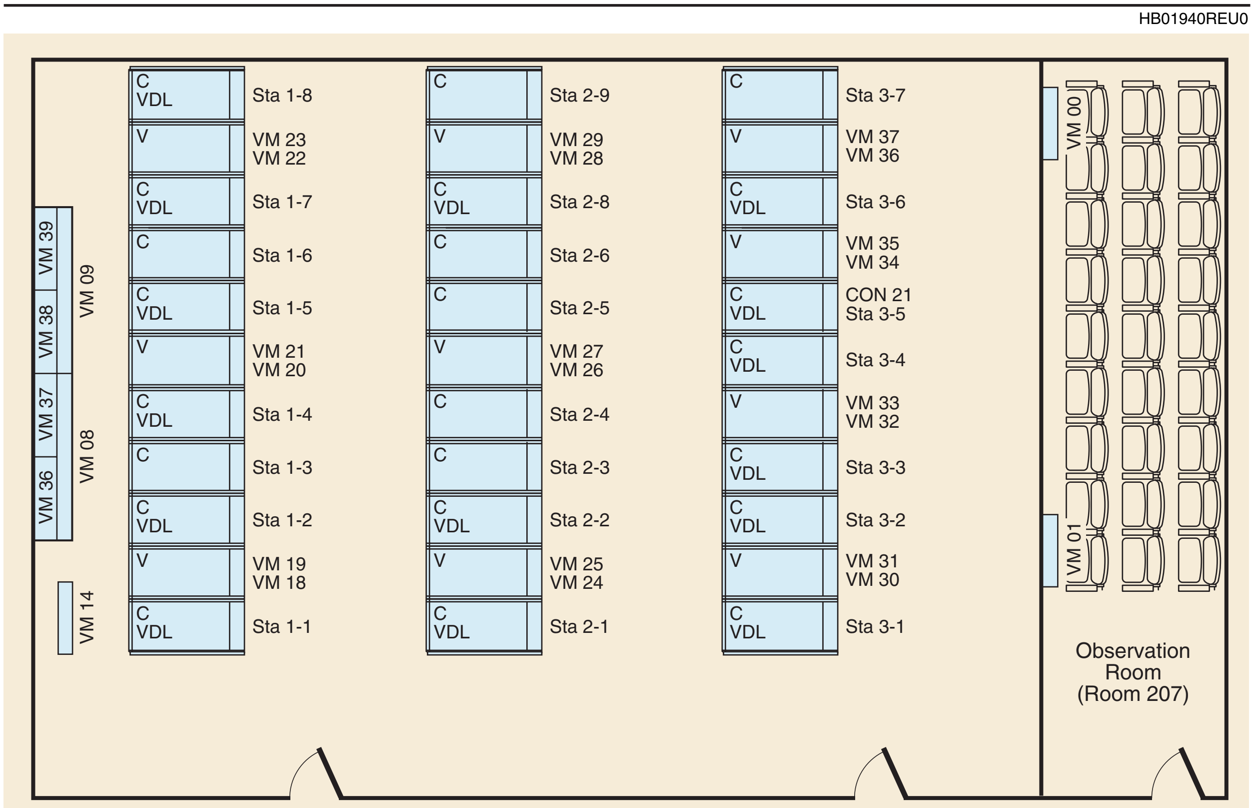


**Figure 7-10. Mission Director Center (Building 840)**

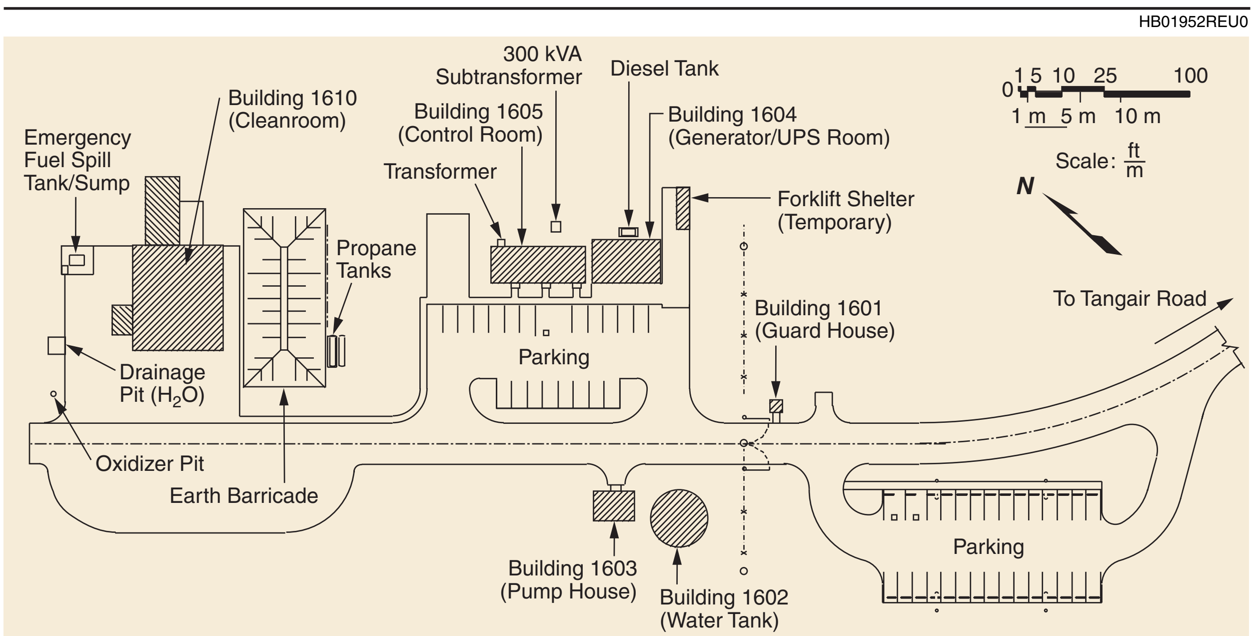


**Figure 7-11. NASA Hazardous Processing Facility**

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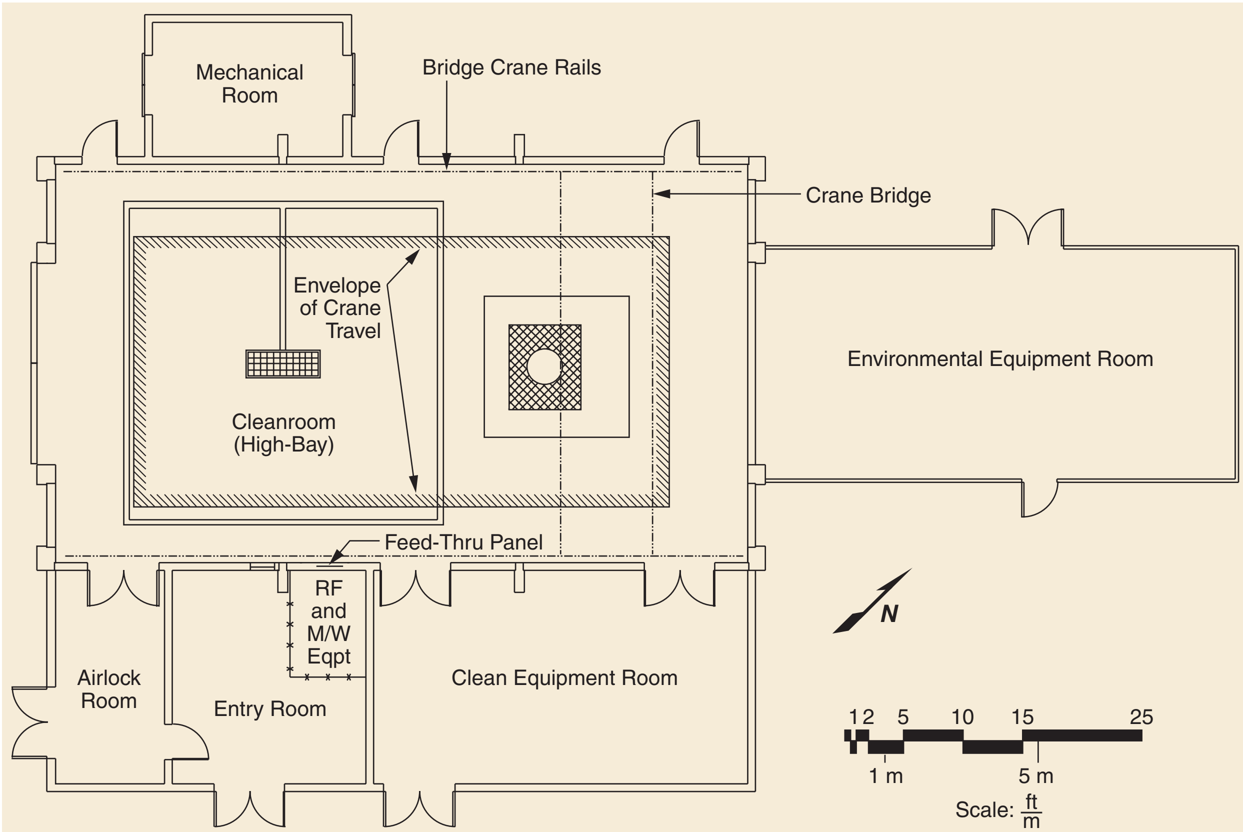


**Figure 7-12. Hazardous Processing Facility (Building 1610)**

propulsion. In the high bay, there is an overhead bridge crane with two 4545-kg (5-ton) capacity hoists. The working hook height is 10.7 m (35 ft). A spreader beam is available that allows use of both 5-ton hoists to lift up to 10 tons. This beam reduces the available hook height by 1 m (3 ft 2 in.) The HPF is a class 10,000 clean facility with positive pressure maintained in the room to minimize contamination from the exterior atmosphere. Positive-pressure clean air is provided by the air circulation and conditioning system located in a covered environmental equipment room at the rear of the building. Personnel gaining entry to the cleanroom from the entry room must wear appropriate apparel and must pass through an airlock. The airlock room has an access door to the exterior so that equipment can be moved into the cleanroom.

**7.2.2.2 Control Room Building.** The control room building (Figure 7-13) contains a control room, an operations ready room, a fabrication room, and a mechanical/electrical room. The control console for the dynamic balancing system is located within the control room. Television monitors and a two-way intercommunications system provide continuous audio and visual monitoring of operations in the spin test building.

**7.2.2.3 UPS/Generator Building.** The UPS/generator building houses a 415-hp, autostart/autotransfer diesel generator. The generator produces 350 kVA, 240/208 VAC, 3-phase, 4-wire

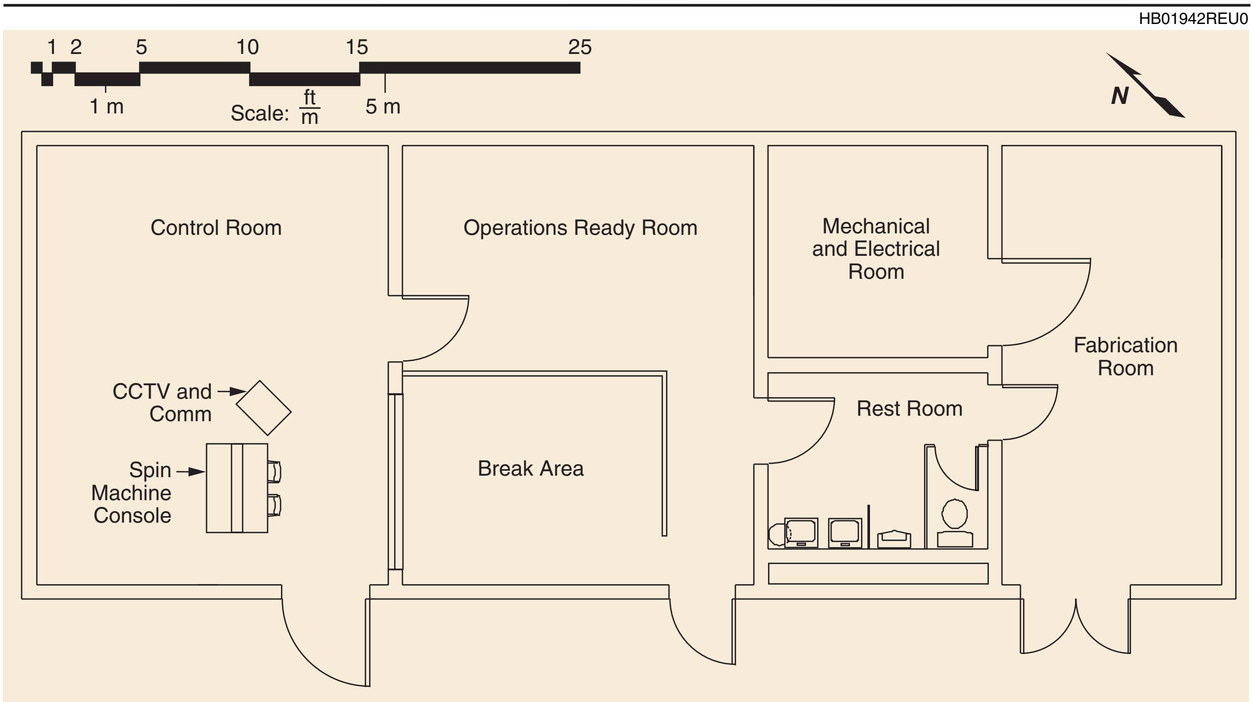


**Figure 7-13. Control Room (Building 1605)**

power. It is capable of carrying the entire facility power load approximately 8 hr after a loss of commercial power without a refueling operation. A 225-kVA uninterruptible power supply is also located in this building, which can carry all on-site power loads (except for HVAC) while the diesel is starting.

### 7.2.3 Astrotech Space Operations Facilities

The Astrotech facilities are located on 24.3 hectares (60 acres) of land at Vandenberg AFB approximately 3.7 km (2 mi) south of the Delta II launch complex (SLC-2) along Tangair Road (Figure 7-14). The complex is situated at the corner of Tangair Road and Red Road adjacent to the Vandenberg AFB runway. This location facilitates convenient support of airstrip operations for receipt of flight hardware and associated ground support equipment. All roadways, parking lots, and aprons are constructed of continuously poured asphalt and contain no curbs or other significant discontinuities. The Astrotech facility is on the Vandenberg fiber-optics network that provides base-wide communications capability. Antenna towers mounted on the building offer the option of line-of-sight radio frequency (RF) communications with SLC-2.

There are five major buildings on the site, as shown in Figure 7-14. A brief description of each building is given below. For further details, request a copy of the Astrotech Facility Accommodation Handbook.

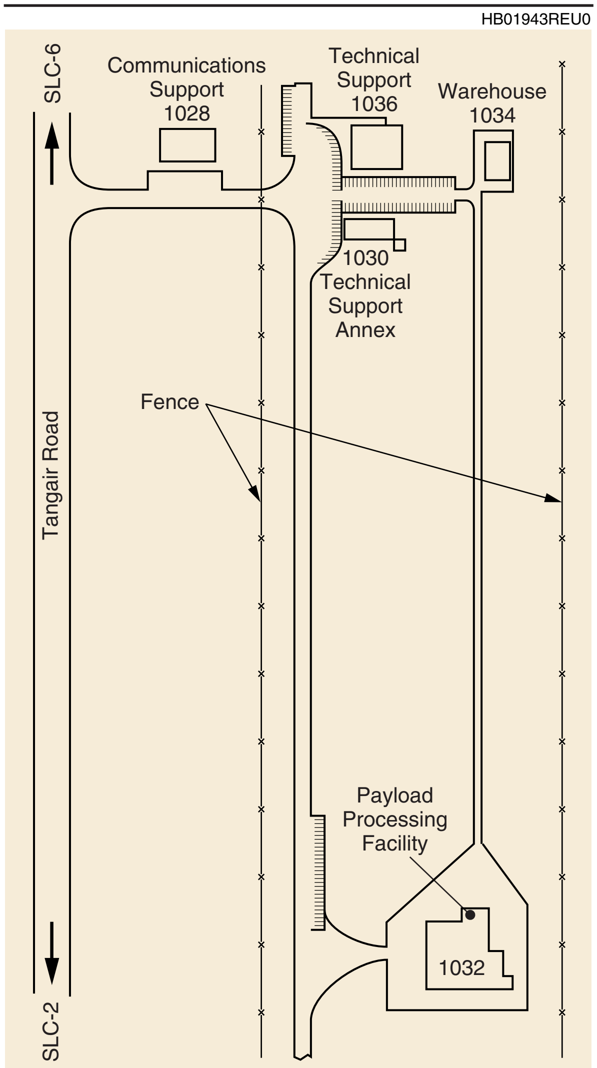


**Figure 7-14. Astrotech Space Operations Facilities**

**7.2.3.1 Astrotech Building 1032.** Building 1032, the payload processing facility (Figure 7-15), is used for all payload preparation operations including liquid-propellant transfer, solid-rocket-motor and ordnance installations, spacecraft/second-stage mating, third-stage preparations, and payload final assembly.

The PPF contains five cleanrooms. All cleanroom high bays, low bays, and airlocks are class 100,000 with demonstrated capability of providing class 10,000 cleanliness. The floor coverings in all areas are made of an electrostatic-dissipating (high-impedance) epoxy-based material.

The west high bay and shared airlock has a floor area measuring 12.2 m (40 ft) by 18.3 m (60 ft) and a clear vertical ceiling height of 13.7 m (45 ft). The west high bay and shared airlock are serviced by a 10-ton overhead crane with a 37-ft hook height. The 10-ton crane is capable of traversing from the airlock to the processing high bay. The two adjacent cleanroom low bays provide 450 ft$^2$ of processing area and have a clear vertical height of 9 ft 4 in.

The east high bay has a floor area measuring 15.3 m (50 ft) by 21.4 m (70 ft) and a clear vertical ceiling height of 20 m (65 ft). The east high bay is serviced by a 30-ton overhead crane with a 16.8-m (55-ft) hook height. The adjacent cleanroom low bay provides an additional 450 ft$^2$ of processing area and also has a clear vertical height of 9 ft 4 in.

Each high bay has a dedicated control room with floor areas as shown in Figure 7-15. Two 4-ft by 8-ft exterior doors provide each control room with easy access to install and remove support equipment. Each control room has a large window for viewing activities in the high bay. Additionally, two cableways run from the control rooms to the high bays to permit electrical cable interface from the control rooms to the high bays. Dedicated garment change rooms support the high bay areas and provide personnel access to them. Limiting access to the high bays through these rooms helps control personnel traffic and maintains a cleanroom environment.

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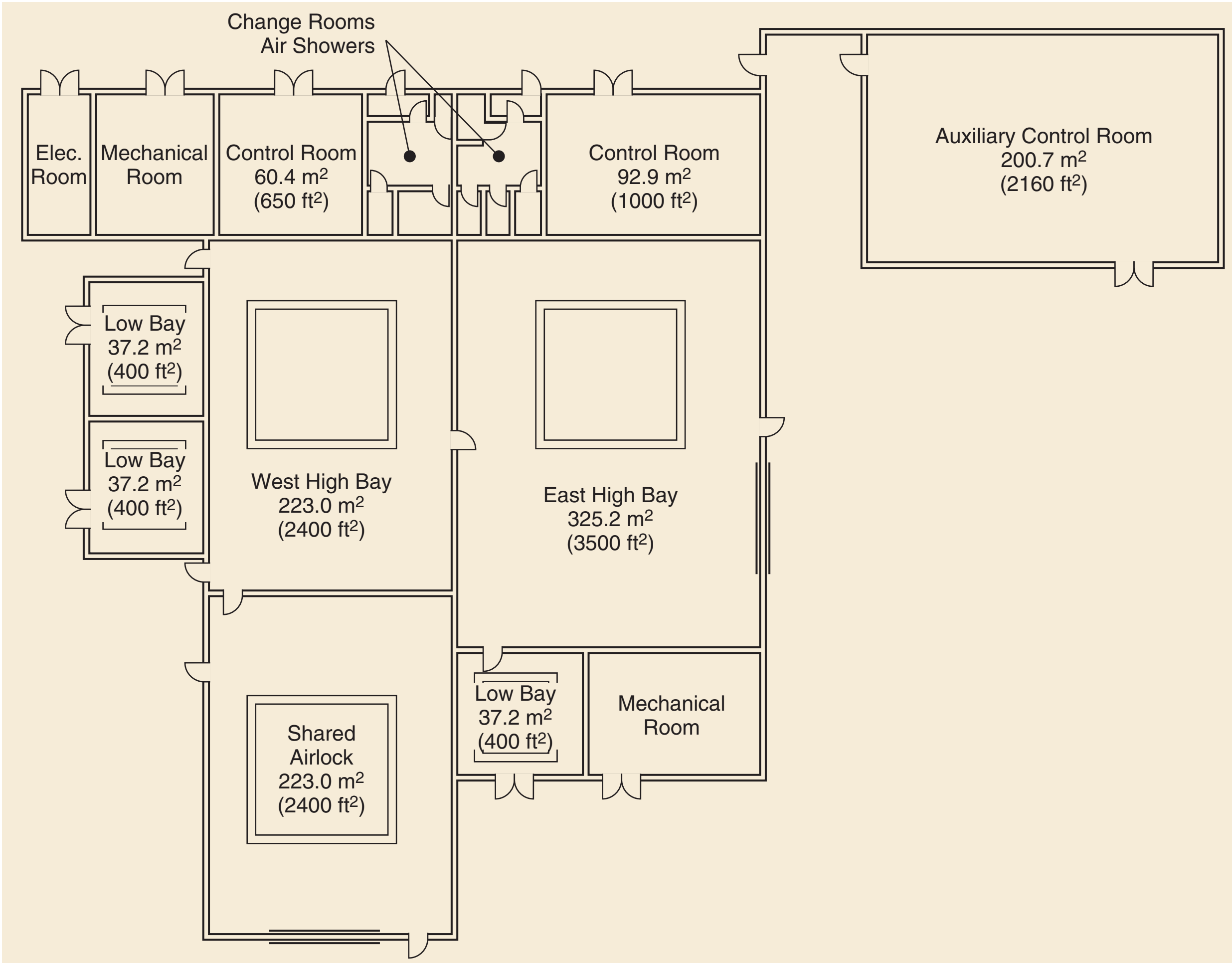


**Figure 7-15. Astrotech Payload Processing Facility (Building 1032)**

**7.2.3.2 Astrotech Building 1028.** Building 1028 is used for communications support and is also capable of providing 111 m$^2$ (1200 ft$^2$) of additional office space if required.

**7.2.3.3 Astrotech Building 1030.** The technical support building annex (Figure 7-16) provides an additional 223 m$^2$ (2400 ft$^2$) of office and conference room space.

**7.2.3.4 Astrotech Building 1034.** The 18.3-m (60-ft) by 12.2-m (40-ft) warehouse is used for limited storage of customer supplies and packing materials. The warehouse has two 20-ft by 20-ft rollup doors on each side of the facility to accommodate easy access and egress of equipment. Inside the warehouse are pallet racks for storing empty crates.

**7.2.3.5 Astrotech Building 1036.** The technical support building (Figure 7-17) is shared by Astrotech resident professionals and customer personnel. The shared support areas include office space, conference room, breakroom, copier, facsimile, and restrooms.

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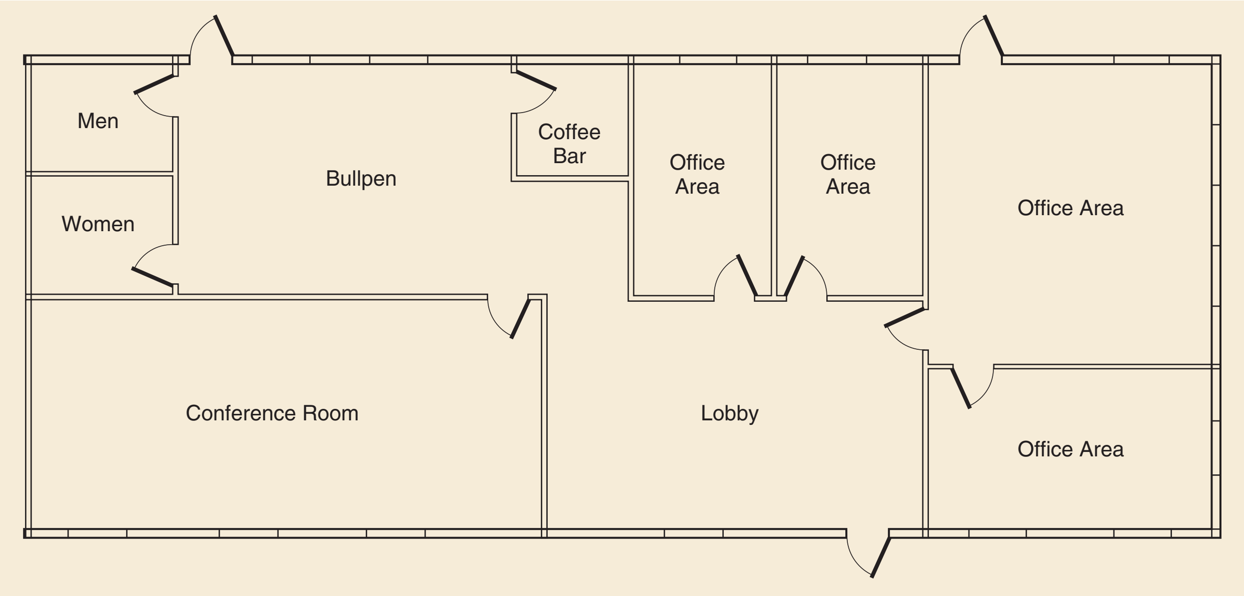


**Figure 7-16. Astrotech Technical Support Annex (Building 1030)**

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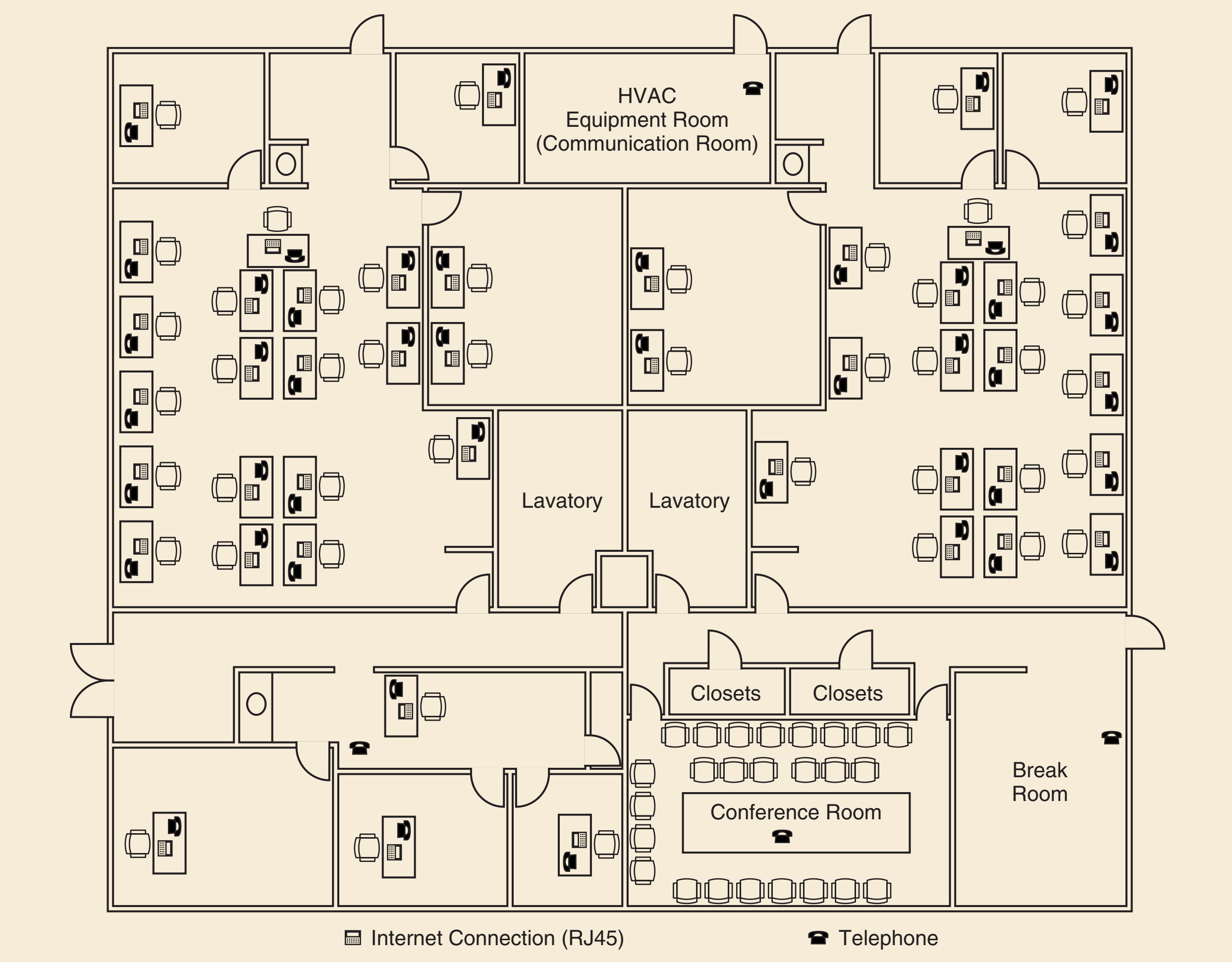


**Figure 7-17. Astrotech Technical Support (Building 1036)**

### 7.2.4 Spaceport Systems International (SSI) Facilities

The SSI payload processing facility is located at SLC-6 on South Vandenberg adjacent to the SSI commercial spaceport. This processing facility is called the integrated processing facility (IPF) because both booster components and payloads (satellite vehicles) can be processed in the building at the same time. This facility, originally built to process classified space shuttle payloads, is now a part of the SSI commercial spaceport facilities. It is composed of two basic areas: the processing areas and the technical support areas. Figures 7-18 and 7-19 illustrate the two major areas: the processing areas located on the north side of the building and the technical support areas on the south side.

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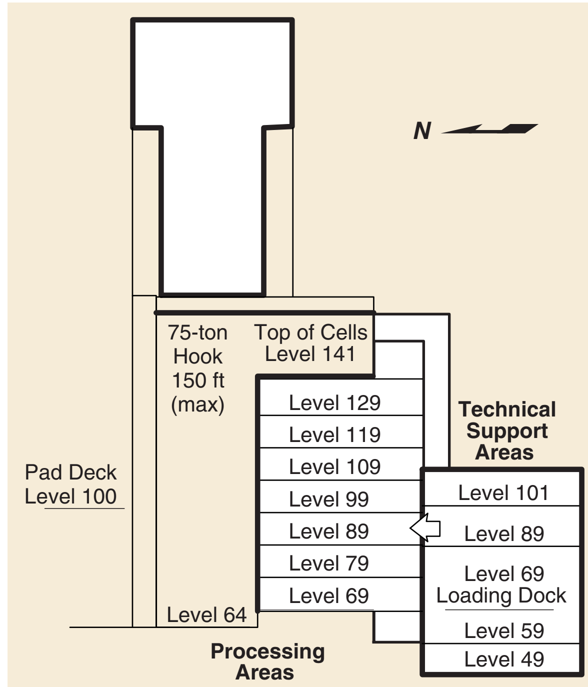


**Figure 7-19. California Spaceport—IPF Cross-Sectional View**

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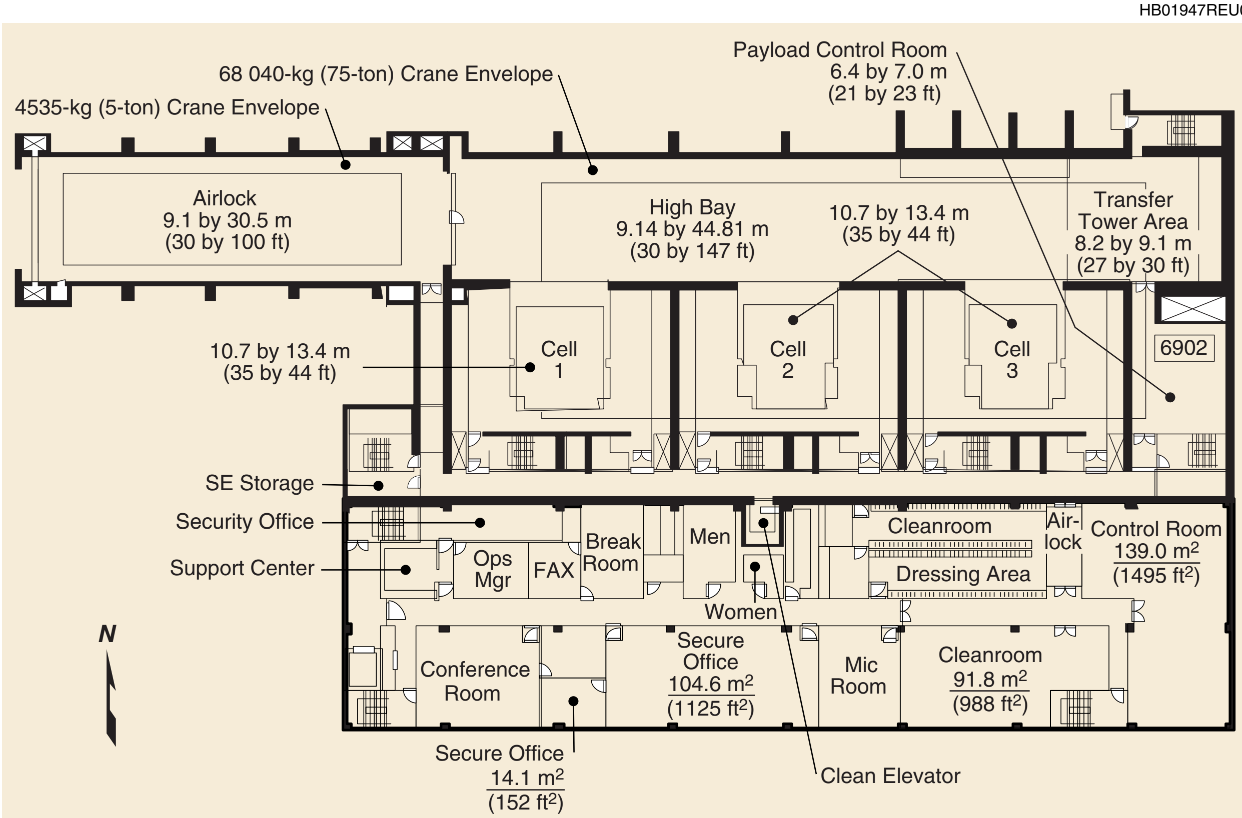


**Figure 7-18. California Spaceport—Plan View of the Integrated Processing Facility**

The cross-sectional view of the IPF shown in Figure 7-19 illustrates the relationships between the technical support area and the processing area level numbers. Level numbers are defined in feet above the SLC-6 launch mount. Rooms on two levels (89 and 101) provide office space and technical support rooms ranging from 14 $m^2$ to 150 $m^2$ (150 $ft^2$ to 1620 $ft^2$). These floors contain both "dirty" and clean elevators, clean dressing areas, tool cleaning areas, a PHE change room, dressing rooms, showers, break room, conference room, and restrooms. An airlock on level 89 separates the technical support area from the processing areas.

**7.2.4.1 Processing Areas.** There are six major processing areas within the IPF:

1. Airlock.
2. High bay.
3. Three payload checkout cells (PCC).
4. Transfer tower area.
5. Fairing storage and assembly area (FSAA).
6. Miscellaneous payload processing rooms (PPR).

There are seven levels on the processing side; six of these can be seen in Figure 7-19. The seventh (fairing storage and assembly area) can be seen in Figure 7-20. The airlock and the high bay are on level 64. The payload checkout cells floor and the transfer tower area are on level 69. In addition to the cell floor at level 69, there are six platform levels in each of the three processing cells: 79, 89, 99, 109, 119 and 129. There are payload processing rooms on each level, providing a total of seven

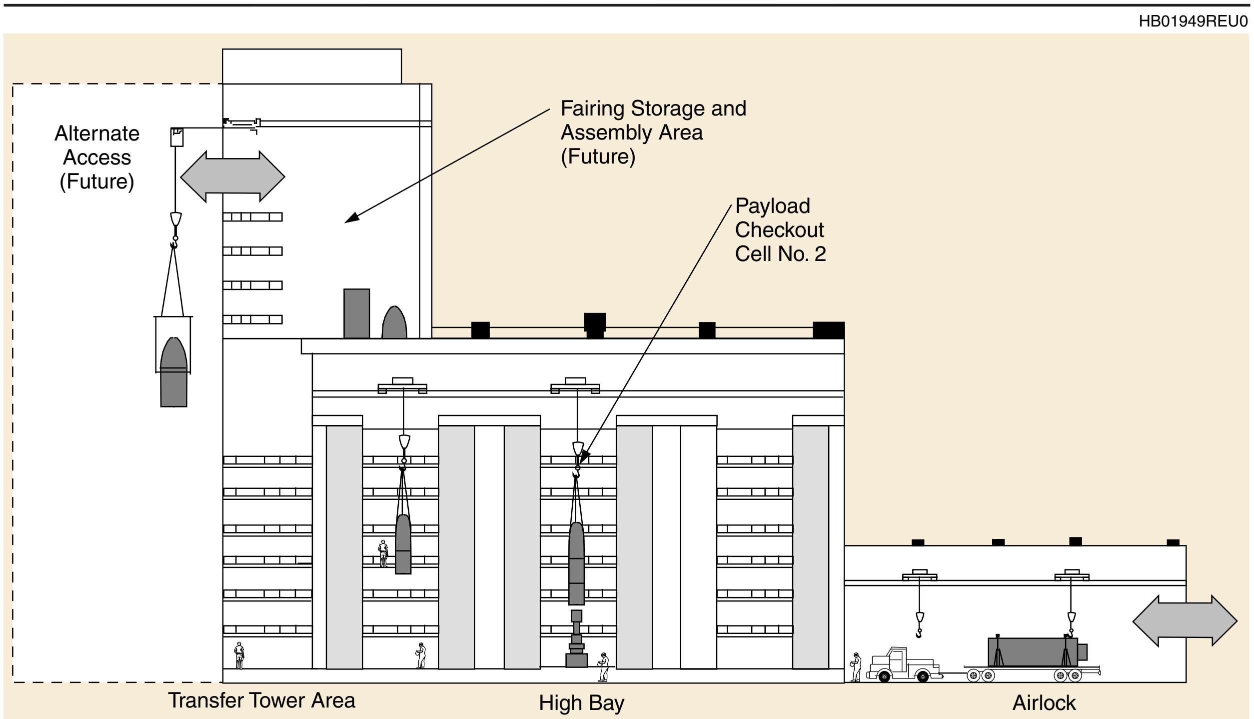


**Figure 7-20. California Spaceport—Cutaway View of the IPF (Looking South)**

rooms similar to the payload processing room shown in Figure 7-18, for small payload processing or processing support. Access is provided to the processing area through the airlock on level 89 of the technical support area.

Figure 7-20 illustrates the IPF as viewed in cut-away looking south and shows the location of the seventh area, the fairing storage and assembly area. This class 100,000 clean area provides the option for fairing storage and build-up prior to encapsulating the payload in the transfer tower area.

Access to the IPF is through the 7.3-m (24-ft)-wide, 9.4-m (31-ft)-high main door on the west side of the airlock. The 9.1-m by 30.5-m (30-ft by 100-ft) class 100,000 clean airlock has two 4.5-metric-ton (5-ton) overhead bridge cranes with a hook height of 10.8 m (35 ft 5 in.). The class 100,000 clean, 9.1-m (30-ft) by 44.8-m (147-ft) high bay is serviced by a 68-metric-ton (75-ton) bridge crane. The hook height in the high bay is 26.3 m (86 ft, 4 in). Access to the high bay is through the 7.3-m (24-ft)-wide by 8.5-m (28-ft) door from the airlock.

The three class 100,000 clean, 10.7-m (35-ft) by 13.4-m (44-ft) payload checkout cells (PCC) are serviced by a 68-metric-ton (75-ton) bridge crane with a 24.8-m (81-ft 4-in.) hook height. Each cell also has 4.5-metric-ton (5-ton) crane support with a hook height of 21.9 m (71 ft 11 in.). Access to each cell is through doors from the high bay with a total opening of 6.4 m (21 ft 2 in.).

Tables 7-1, 7-2, 7-3, 7-4, 7-5, 7-6, 7-7, and 7-8 detail some of the capabilities in each of the processing areas. They define constraints, customer-provided equipment, and technical capability summaries in nine categories: space/access, handling, electrical, liquids, pneumatics, environmental control, safety, security, and communications.

Some dimensions of the processing areas are summarized in Figure 7-21. Also shown are the crane envelopes for the 4.5-metric-ton (5-ton) cranes in the airlock; the 68-metric-ton (75-ton) cranes servicing the high bay, the checkout cells, and the transfer tower area; and the checkout cell 4.5-metric-ton (5-ton) cranes. Vehicles and equipment enter through the main entry door in the west end of the airlock. Personnel and support equipment access to the checkout cells is provided through the airlock on level 89 of the technical support area. There is also a personnel airlock entry door on the south side of the airlock. The level 69 payload processing room (6902) is shown in Figure 7-21; there are also rooms available on Levels 99, 109, 119, and 129. The rooms are 4.9 m (16 ft) by 7.0 m (23 ft).

**7.2.4.2 Technical Support Areas.** Figures 7-22 and 7-23 illustrate the plan views of the IPF, showing levels 89 and 101 of the technical support side. (Level numbers are defined in feet, with the SLC-6 launch mount defined as level 100). These figures show room sizes as well as potential functions. Note that the clean elevator can only be accessed from the technical support

**Table 7-1. Airlock**

| Capability type | Capability |
|---|---|
| 1. Space/access | ■ Floor loading -or mobile equipment meets AASHTO H-20<br>■ 9.1-m by 30.5-m (30-ft by 100-ft) internal floor space<br>■ 7.3-m by 8.5-m (24-ft-wide by 28-ft-high) door openings<br>■ Adjacent to washdown area outside<br>■ Accept tow vehicle/transporter of 61 m by 27.4 m (20 ft by 90 ft) |
| 2. Handling | ■ Two 4.5-metric-ton (5-ton) overhead bridge cranes<br>■ Crane maximum hook height of 10.8 m (35 ft 5 in.)<br>■ Speeds<br>– Hoist 16 fpm<br>– Bridge 14 fpm<br>– Trolley 14 fpm<br>■ Pendant control at elevation 19.5 m (64 ft) (floor) |
| 3. Electrical | ■ Utility and technical power 120/208 VAC<br>■ Hazard-proof electrical equipment as defined in the National Electrical Code, Articles 500–516<br>■ Multipoint grounding per MIL-STD-1542 |
| 4. Liquids | ■ Cleaning water supply<br>– 100 gpm at 80 psig<br>– 3.8-cm (1.5-in.) male hose thread |
| 5. Pneumatics | ■ Compressed air 125 psig<br>– 1-cm (3/8-in.) quick-disconnect (QD) interface |
| 6. Environment | ■ Buffer for operations between external environment and high bay area<br>■ Class 100,000 cleanroom capability<br>– Inlet air Class 5000<br>– Temperature 60°F to 70°F controlled within ±1°F<br>– RH 35% to 50% controlled within ±5%<br>– Dif 1.3-mm (0.05-in.) Wg<br>– Air chg 10 to 12 changes/hr min<br>■ Central vacuum system |
| 7. Safety | ■ All electrical equipment is hazard-proof as defined in the National Electrical Code, Articles 500–516<br>■ Fire-detection and -suppression system |
| 8. Security | ■ Access control<br>– KeyCard/cipher system<br>– Intrusion-detection system (BMS switches)<br>– Vault doors with S&G three-position tumbler<br>– Lockable personnel and hardware access doors |
| 9. Communications | ■ Administrative phone<br>■ Operational voice system (OVS)<br>■ Area warning system<br>■ Paging system<br>■ CCTV<br>■ MM/SM fiber-optics<br>■ Ethernet |

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side on level 89 through the airlock (for support equipment) or the clean change room. From the elevator, any level on the processing side can be accessed.

The two rooms currently in use as payload control rooms are 7903 and 8910. Data and power cable route access is provided from rooms 7903 and 8910 to the cells.

Room 7903, located on the hardened side of the IPF immediately adjacent to checkout cell 3 on level 79, provides 39.5 $m^2$ (34.5 $m^2$ net) (425 $ft^2$ ([371 $ft^2$ net]) and has a raised floor. It is located immediately above Room 6902 (the payload control room shown in Figure 7-18 to the right of cell 3).

Room 8910, located on level 89 of the unhardened side of the IPF, provides 138.9 $m^2$ (1495 $ft^2$). The location of this control room is shown in Figure 7-22 at the far right.

**Table 7-2. High Bay**

| Capability type | Capability |
|---|---|
| 1. Space/access | ■ Floor loading for mobile equipment meets AASHTO H-20<br>■ Work space approximately 0.76 m by 44.7 m (30 in. by 146 ft 9 in.)<br>■ Adjacent to Transfer Tower Area and payload checkout cells |
| 2. Handling | ■ 68-metric-ton (75-ton) overhead bridge main crane (currently proof-loaded to (26 metric tons [29 tons])<br>■ Hook height<br>– High bay 26.3 m (86 ft 4 in.) above floor (floor at elev 19.5 m [64 ft])<br>– Checkout 24.8 m (81 ft 4 in.) maximum above cells floor (floor at elev 21.0 m [69 ft])<br>– Transfer 24.8 m (81 ft 4 in.) maximum above tower floor (floor at elev 21.0 m [69 ft])<br>■ Speeds<br>– Hoist 10 fpm<br>– Bridge E/W 15 fpm and 30 fpm<br>– Trolley N/S 15 fpm and 10 fpm<br>■ Microdrive<br>– Hoist 0.5 and 1.5 fpm<br>– Bridge 0.5 fpm<br>– Trolley 0.5 fpm<br>■ Two portable pushbutton stations with 18.3-m (60-ft) flex cable |
| 3. Electrical | ■ Utility and technical power 120/208 VAC<br>■ Hazard-proof electrical equipment as defined in the National Electrical Code, Articles 500–516<br>■ Multipoint grounding per MIL-STD-1542 |
| 4. Liquids | ■ None |
| 5. Pneumatics | ■ Gaseous nitrogen ($GN_2$) |
| 6. Environment | ■ Class 100,000 cleanroom capability<br>– Inlet air Class 5000<br>– Temperature 60°F to 75°F controlled within ±1°F<br>– RH 35% to 50% controlled within ±5%<br>– Dif 1.3-mm (0.05-in.) Wg<br>– Air chg 10 to 12 changes/hr min<br>■ Central vacuum system |
| 7. Safety | ■ All electrical equipment is hazard-proof as defined in the National Electrical Code, Articles 500–516<br>■ Fire-detection and -suppression system (suppression system currently inactivated) |
| 8. Security | ■ Access control<br>– KeyCard/cipher system<br>– Intrusion-detection system (BMS switches)<br>– Lockable personnel and hardware access doors |
| 9. Communications | ■ Administrative phone<br>■ Operational voice system (OVS)<br>■ Area warning system<br>■ Paging system<br>■ CCTV<br>■ Ethernet<br>■ SM/MM fiber-optics |

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**Table 7-3. Payload Checkout Cells' Capabilities**

| Capability type | Capability |
|---|---|
| 1. Space/access | ■ Design floor loading<br>– 100 psf on checkout cell floor<br>– 75 psf plus a 1.8-metric-ton (4000-lb) load on four casters (4 ft by 6 ft) on fixed platforms<br>– 50 psf plus a 540-kg (1200-lb) load on folding platforms<br>■ Work space approximately 10.7 m by 13.4 m (35 ft by 44 ft)<br>■ Cell door opening 6.5 m wide by 21.6 m high (21 ft 2 in. wide by 71 ft high)<br>■ Adjacent to Transfer Tower Area and high bay<br>■ Six working platform levels (fixed and fold-down plus finger planks in Cells 2 and 3), spaced 3 m (10 ft) apart |
| 2. Handling | ■ 4.5-metric-ton (5-ton) overhead bridge crane<br>■ Hook height (floor at elev 69 ft)<br>– Cell 1 21.8 m (71 ft 6 in.) above floor<br>– Cell 2 21.9 m (71 ft 11 in.) above floor<br>– Cell 3 21.7 m (71 ft 4.5 in.) above floor<br>■ Speeds<br>– Hoist 16 fpm (Cells 2/3<br>10 fpm (Cell 1)<br>– Bridge E/W 10 fpm<br>– Trolley N/S 10 fpm (Cell 1)<br>5 fpm (Cell 2)<br>17 fpm (Cell 3)<br>■ Microdrive<br>– Hoist 0.5 fpm<br>– Bridge 0.5 fpm<br>– Trolley 0.5 fpm<br>■ Portable pushbutton station with 13.7-m (45-ft) flex cable connected to receptacle on northeast corner of cell on any level |
| 3. Electrical | ■ Utility and technical power 120/208, 408 VAC<br>■ Multipoint grounding per MIL-STD-1542 |
| 4. Liquids | ■ Cleaning water supply<br>– 50 gpm at 80 psig<br>– 2.54-cm (1-in.) hose bib with 2.54-cm (1-in.) male hose thread on south wall of each level<br>■ Hypergolic |
| 5. Pneumatics | ■ Compressed air 125 psig<br>1-cm (3/8-in.) QD at two locations per cell |
| 6. Environment | ■ Class 100,000 cleanroom capability (Class 5000 HEPA)<br>– Inlet air Class 5000<br>– Temperature 60°F to 75°F controlled within ±1°F<br>– RH 35% to 50% controlled within ±5%<br>– Dif 1.3-mm (0.05-in.) Wg<br>– Air chg 15 to 17 changes/hr min<br>■ Central vacuum system<br>■ Toxic-vapor detection system<br>■ Continuous monitoring, alarm, and trending of particle count, humidity, temperature, and pressure |
| 7. Safety | ■ All electrical equipment is hazard-proof as defined in the National Electrical Code, Articles 500–516<br>■ Fire-detection and -suppression system (dry pipe, manual valve) |
| 8. Security | ■ Access control<br>– KeyCard/cipher system<br>– Intrusion-detection system (BMS switches)<br>– Vault doors with S&G three-position tumbler<br>– Lockable personnel and hardware access doors |
| 9. Communications | ■ Administrative phone<br>■ Operational voice system (OVS)<br>■ Area warning system<br>■ Paging system<br>■ CCTV<br>■ RF closed loop<br>■ GPS signal<br>■ IRIG<br>■ MM/SM fiber-optics<br>■ Ethernet |

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**Table 7-4. Transfer Tower Area**

| Capability type | Capability |
|---|---|
| 1. Space/access | ■ 8.2-m by 9.1-m (27-ft by 30-ft) clear floor access<br>■ Design floor loading is 100 psf<br>■ Seven platforms on three sides (north, east, and south)<br>– 75 psf loading on platforms |
| 2. Handling | ■ 68-metric-ton (75-ton) stationary hoist<br>■ Hook height of 50.8 m (166 ft 6 in.) above floor elevation 1.8 m (69 in.)<br>■ Speeds<br>– Hoist 0.5, 5.0 and 10 fpm<br>■ Pendant control at elevation 42.4 m (139 ft 0 in.) and 50.5 m (165 ft 7 in.) |
| 3. Electrical | ■ Utility power<br>– 110 VAC<br>■ Hazard-proof electrical equipment as defined in the National Electrical Code, Articles 500–516<br>■ Static grounding reel |
| 4. Liquids | ■ None |
| 5. Pneumatics | ■ Compressed air 125 psig<br>– 1-cm (3/8-in.) QD interface |
| 6. Environment | ■ Class 100,000 cleanroom capability<br>– Inlet air Class 5000<br>– Temperature 70°F ±5°F<br>– RH 30% to 50%<br>– Dif 1.3-mm (0.05-in.) Wg<br>– Air chg 10 to 12 changes/hr min<br>■ Central vacuum system |
| 7. Safety | ■ All electrical equipment is hazard-proof as defined in the National Electrical Code, Articles 500–516<br>■ Fire-detection and -suppression system |
| 8. Security | ■ Access control<br>– KeyCard/cipher system<br>– Intrusion-detection system (BMS switches)<br>– Vault doors with S&G three-position tumbler<br>– Lockable personnel and hardware access doors |
| 9. Communications | ■ Administrative phone<br>■ Operational voice system (OVS)<br>■ Area warning system<br>■ Paging system<br>■ Ethernet |

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**Table 7-5. Fairing Storage and Assembly Area**

| Capability type | Capability |
|---|---|
| 1. Space/access | ■ Floor loading 75 psf on platforms<br>■ 9.8-m by 19.2-m (32-ft by 63-ft) internal floor space<br>■ 6.7-m-wide by 20.9-m-high (22-ft-wide by 68-ft 6-in.-high) breechload door opening |
| 2. Handling | ■ 68-metric-ton (75-ton) stationary hoist<br>■ Hook height of 50.8 m (166 ft 6 in.) above floor elevation 1.8 m (69 in.)<br>■ Speeds<br>– Hoist 0.5, 5.0 and 10 fpm<br>■ Pendant control at elevation 42.4 m (139 ft 0 in.) and 50.5 m (165 ft 7 in.) |
| 3. Electrical | ■ 110 VAC, utility power<br>■ Hazard-proof electrical equipment as defined in the National Electrical Code, Articles 500–516<br>■ Multipoint grounding per MIL-STD-1542 |
| 4. Liquids | ■ None |
| 5. Pneumatics | ■ Compressed air 125 psig<br>– 1-cm (3/8-in.) QD interface |
| 6. Environment | ■ Class 100,000 cleanroom capability<br>– Inlet air Class 5000<br>– Temperature 70°F ± 5°F<br>– RH 30 to 50%<br>– Dif 1.3-mm (0.05-in.) Wg<br>– Air chg 10 to 12 changes/hr min<br>■ Central vacuum system |
| 7. Safety | ■ All electrical equipment is hazard-proof as defined in the National Electrical Code, Articles 500–516<br>■ Fire-detection and -suppression system |
| 8. Security | ■ Access control<br>– KeyCard/cipher system<br>– Intrusion-detection system (BMS switches)<br>– Lockable personnel and hardware access doors |
| 9. Communications | ■ Paging system |

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**Table 7-6. Payload Processing Room 6902**

| Capability type | Capability |
|---|---|
| 1. Space/access | ■ Processing/storage room 6902:<br>– 6.5 m by 7 m (21 ft 5 in. by 23 ft)<br>– 150.9 $m^2$ (495 $ft^2$)<br>■ Door openings shall accommodate an envelope of 1.2 m by 1.8 m by 2.1 m (4 ft by 6 ft by 7 ft) |
| 2. Handling | ■ None |
| 3. Electrical | ■ 110 VAC, utility power<br>■ 120/208 VAC 3-phase<br>■ Multipoint grounding per MIL-STD-1542<br>■ Hazard-proof electrical equipment as defined in the National Electrical Code, Articles 500–516 |
| 4. Liquids | ■ None |
| 5. Pneumatics | ■ None |
| 6. Environment | ■ Class 100,000 cleanroom capability<br>– Inlet air Class 5000<br>– Temperature 70°F ±5°F<br>– RH 30% to 50%<br>– Dif 1.3-mm (0.05-in.) Wg<br>– Air chg 15 changes/hr min |
| 7. Safety | ■ Fire-detection and -suppression system |
| 8. Security | ■ Access control<br>– KeyCard/cipher system<br>– Intrusion-detection system (BMS switches)<br>– Lockable personnel and hardware access doors |
| 9. Communications | ■ Ethernet |

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**Table 7-7. Payload Control Room 7903**

| Capability type | Capability |
|---|---|
| 1. Space/access | ■ 4.8 m by 8.2 m (15 ft 9 in. by 27 ft 0 in.) (effective: 34.5 $m^2$ [371 $ft^2$]) with 12-in. raised floor<br>■ Actual door opening 1.8 m wide by 2.4 m high (5-ft 11-in. wide by 7-ft 10-in. high)<br>■ Cable path length<br>– Cell 1 67 m (~220 ft)<br>– Cell 2 50.3 m (~165 ft)<br>– Cell 3 21.3 m (70 ft) |
| 2. Handling | None |
| 3. Electrical | ■ 110 VAC utility power<br>■ 120/208 VAC 3-phase<br>■ Facility and technical grounds |
| 4. Liquids | None |
| 5. Pneumatics | None |
| 6. Environment | 4-ton stand-alone HVAC system (48,000 Btu/hr) |
| 7. Safety | None |
| 8. Security | ■ Access Control<br>– CardKey/cipher system<br>– Intrusion-detection system (BMS switches)<br>– Lockable personnel and hardware access doors |
| 9. Communications | ■ Paging<br>■ Area warning system control<br>■ Single and multimode fiber-optic interfaces<br>■ 20/24-key operational voice system (OVS) panels<br>■ Range fiber-optic transmission system (FOTS) interface for digital and analog data<br>■ Ethernet RJ-45 interfaces<br>■ IPF internal LAN interfaces<br>■ IRIG-B and countdown<br>■ RF transmission interface (to FOTS or open loop to SLC-2 or the SSI Commercial Launch Facility)<br>■ CCTV camera control<br>■ CCTV monitors<br>■ Telephone lines<br>■ Film camera control<br>■ Status and alert<br>■ GPS signal |

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**Table 7-8. Payload Control Room 8910**

| Capability type | Capability |
|---|---|
| 1. Space/access | ■ 10.9 m by 9.1 m (35 ft by 6 in. by 30 ft) 7.2 m by 7.2 m (23 ft 6 in. by 23 ft 6 in.)(138.9 $m^2$ [1495 $ft^2$] total)<br>■ Actual door opening 1.8 m wide by 2.4 m high (5 ft 11 in. wide by 7 ft 10 in. high)<br>■ Cable path length<br>– Cell 362.4 m (1189 ft)<br>– Cell 650.4 m (2134 ft)<br>– Cell 115.5 m (379 ft) |
| 2. Handling | None |
| 3. Electrical | ■ All power through 50 kVA UPS<br>■ 110 VAC utility power<br>■ 120/208 VAC 3ph<br>■ Facility and Technical Grounds |
| 4. Liquids | None |
| 5. Pneumatics | None |
| 6. Environment | 9.9-metric-ton (11-ton) stand-alone backup HVAC system |
| 7. Safety | None |
| 8. Security | ■ Access Control<br>– CardKey™/cipher system<br>– Intrusion Detection system (BMS switches)<br>– Lockable personnel and hardware access doors |
| 9. Comm | ■ Paging<br>■ Area Warning System control<br>■ Single and multi-mode fiber optic interfaces<br>■ 20/24-key Operational Voice System (OVS) panels<br>■ Range Fiber-Optic Transmission System (FOTS) interface for digital and analog data<br>■ Ethernet RJ-45 interfaces<br>■ IPF Internal LAN interfaces<br>■ IRIG-B and Countdown<br>■ RF transmission interface (to FOTS or open loop to SLC-2 or the SSI Commercial Launch Facility)<br>■ CCTV camera control<br>■ CCTV monitors<br>■ Telephone lines<br>■ GPS signal |

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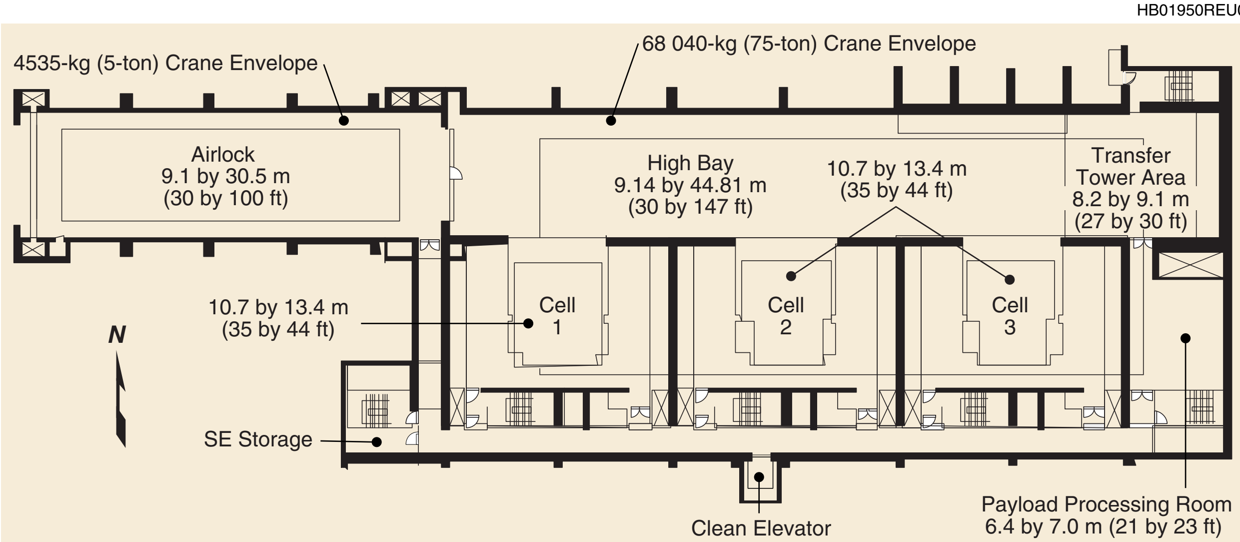


**Figure 7-21. California Spaceport—Processing Areas**

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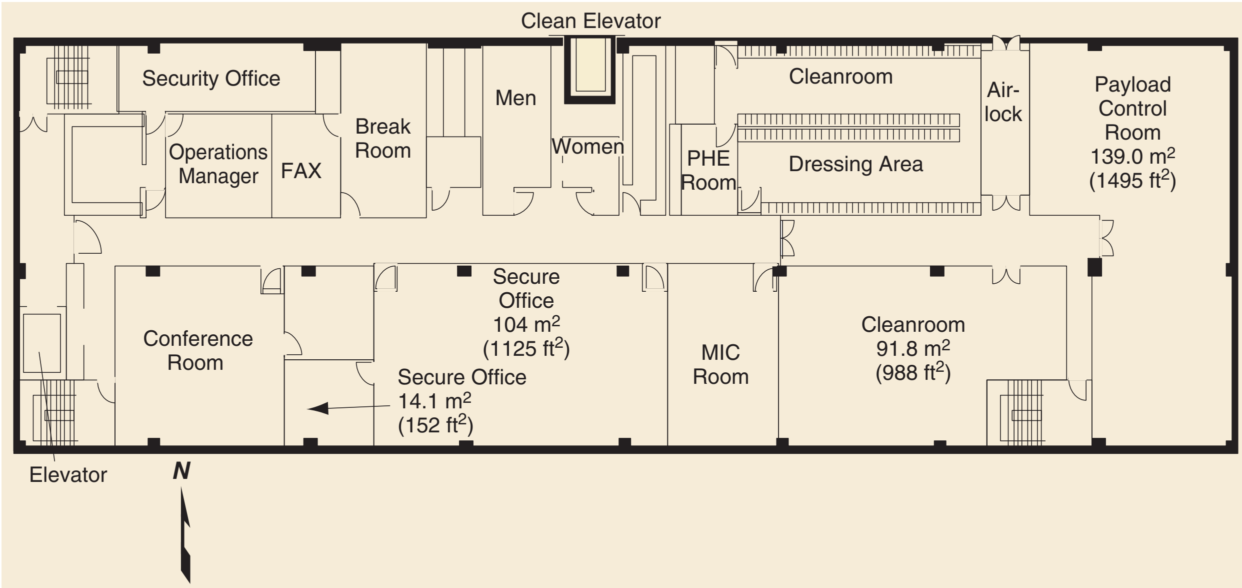


**Figure 7-22. California Spaceport—Level 89 Technical Support Area**

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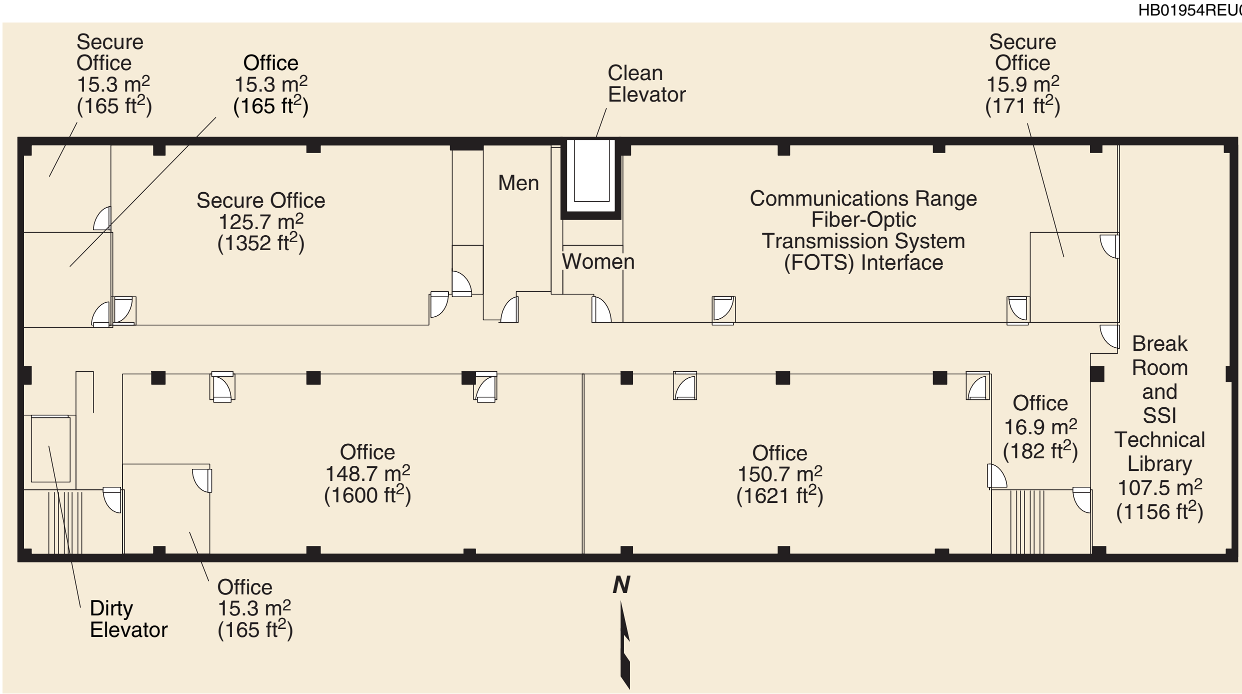


**Figure 7-23. California Spaceport—Level 101 Technical Support Area**

In addition to room 8910, rooms 6902, 9903, 10903, 11903, and 14100 are also available for conversion into additional processing control “annexes.” Room 8903 is the launch control center for the SSI commercial launch facility and can be used as a payload control room.

## 7.3 PAYLOAD ENCAPSULATION AND TRANSPORT TO LAUNCH SITE

Delta IV provides fueled payload encapsulation in the fairing at the payload processing facility. This capability enhances payload safety and security while mitigating contamination concerns, and greatly reduces launch pad operations in the vicinity of the payload.

Payload integration with the PAF and encapsulation in the fairing is planned using either Astrotech or SSI facilities for government, NASA, or commercial payloads. The Astrotech facilities can accommodate payload encapsulation for 4-m fairing (Delta IV-M, Delta IV-M+ [4,2]) launch vehicles, and with modifications, can accommodate all Delta IV launch vehicle configurations. With modifications, the SSI facilities can also accommodate all Delta IV launch vehicle configurations. For purposes of this document, discussions are limited to Astrotech and SSI facilities.

Prior to or after payload arrival, the fairing and PAF enter a high bay to be prepared for payload encapsulation. The fairing bisectors or trisectors are staged horizontally on roll transfer dollies. The PAF is installed on the Boeing buildup stand and prepared for payload mate. After payload arrival and premate operations are completed, including payload weighing, if required (a certified weight statement will suffice), the payload is mated to the PAF and integrated checkout is performed. The previously prepared fairing bisectors or trisectors are then moved into position for final mate, and the personnel access platforms are positioned for personnel access to the fairing mating plane. (These access platforms can also be used for payload access prior to fairing mate.) Interface connections are made and verified. A final payload telemetry test, through the fairing, can be accommodated at this time. The encapsulated payload is transferred to the transporter provided by Boeing and prepared for transport to the launch pad. Environmental controls are established, and a protective cover is installed. The basic sequence of operations is illustrated in Figure 7-24.

The payload is transported to the launch pad at a maximum speed of 8 km/hr (5 mph). The encapsulated fueled payload is environmentally controlled during transportation. During payload hoist onto the launch vehicle, no environmental control system (ECS) services will be provided to the spacecraft. If ECS service is required during payload hoist operation, that service will be negotiated with the customer. Boeing uses PC-programmed monitors to measure and record the transport dynamic loads. The transport loads will be less than flight loads and will be verified by pathfinder tests (if required) prior to first use with the payload.

After arrival at SLC-6, environmental control is discontinued, and the encapsulated payload is lifted into the mobile service tower (MST) and immediately mated to the second stage. Environmental control is re-established as soon as possible with class 5000 air. Should subsequent operations require access through the fairing, a portable clean environmental shelter will be erected over the immediate area to prevent payload contamination.

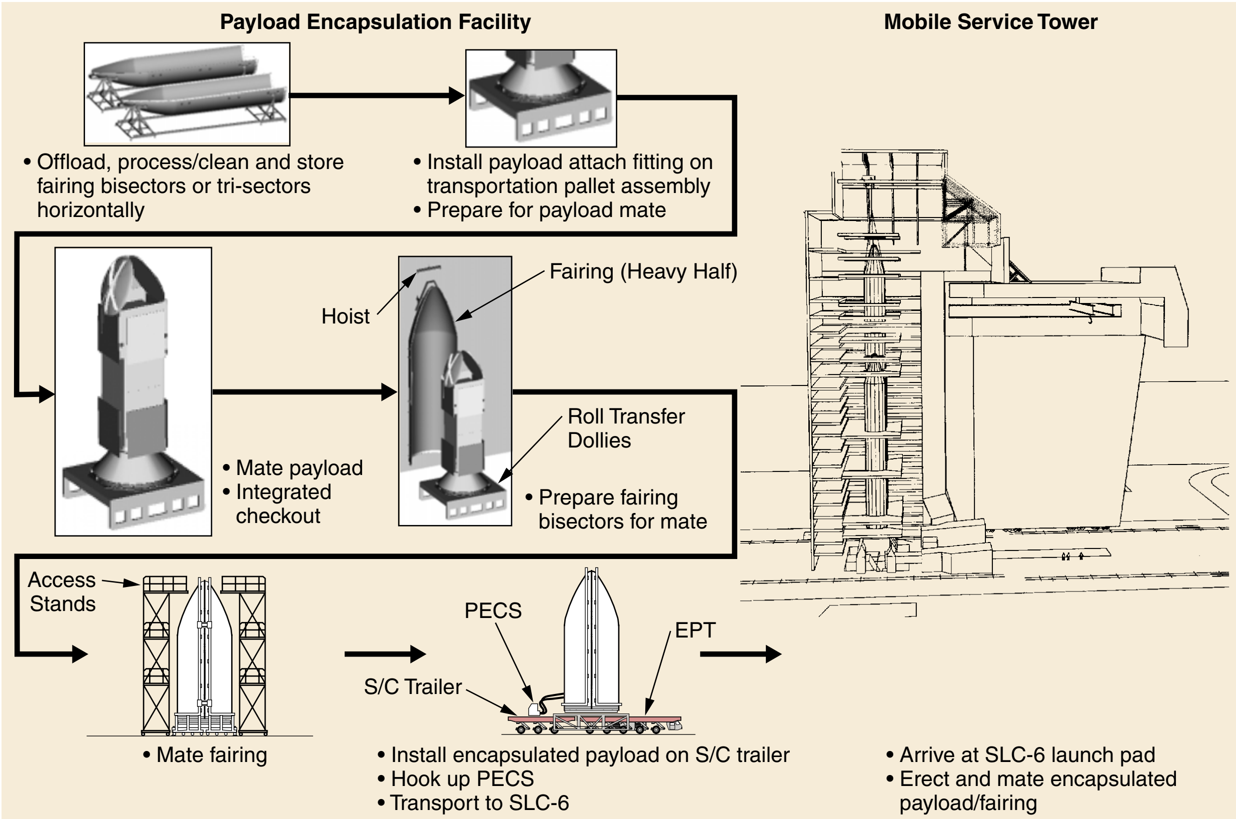


**Figure 7-24. Payload Encapsulation, Transport, and On-Pad Mate—4-m Fairing Example**

## 7.3.1 Payload Processing Facility Analysis for Delta IV Encapsulation

This analysis provides an overview of the PPFs located at the WR and identifies those that are suitable for Delta IV encapsulation operations without modification. With the exception of the IPF at VAFB, only those facilities thought to be possible candidates for payload encapsulation were evaluated. The facility dimensions, door openings, and crane/hoist ratings and hook heights were evaluated and compared to the estimated requirements for encapsulating the Delta IV-M, Delta IV-M+, and Delta IV-H payloads (Table 7-9). The facility specifications are outlined in the payload processing facility matrix (Table 7-10).

**Table 7-9. Delta IV Payload Encapsulation Facility Requirements**

| Vehicle fairing | Floor space | Crane hook height | Door opening | Fairing lay-down area |
|---|---|---|---|---|
| 4-m fairings | 12.2-m by 18.3-m; 223.1 $m^2$ (40 ft by 60 ft; 2400 $ft^2$) | 14.6 m (48 ft) | 12.5-m h by 5.5-m w (41 ft h by 18 ft w) | 8.5-m by 10.7-m (28 ft by 35 ft) |
| 5-m fairings | 11.6-m by 22.3-m; 257.8 $m^2$ (38 ft by 73 ft; 2774 $ft^2$) | 25 m (82 ft) | 22.3-m h by 6.1-m w (73 ft h by 20 ft w) | 9.1-m by 20.1-m (30 ft by 66 ft) |

These facility requirements are preliminary, based on operations analysis. A design analysis of encapsulation processes and facility needs has not yet been accomplished. It is assumed that the floor space requirements can be adjusted to fit facility floor plans, within reason, through operational modifications to the standard process.

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**Table 7-10. Payload Processing Facility Matrix**

| Facility | Location | Number of payloads (cap.) | Work area/bay cleanliness classification Size: WxLxH | Bay access opening WxH | Bay hoist equipment max. hook height (ft) | Airlock size: WxLxH | Airlock access opening WxH | Airlock hoist equip. max. hook height ft | Other information | Encap compatibility |
|---|---|---|---|---|---|---|---|---|---|---|
| Astrotech Space Operations | VAFB | Multiple | Class 100,000 Room 106 12.2 m by 18.3 m by 14.3 m (40 ft by 60 ft by 47 ft) Room 117 15.2 m by 21.3 m by 19.8 m (50 ft by 70 ft by 65 ft) | Room 106 6.1 m by 12.2 m (20 ft by 40 ft by 40 ft) Room 117 6.1 m by 13.4 m (20 ft by 44 ft) External door 6.1 m by 15.2 m (20 ft by 50 ft) | Room 106 One 9070-kg (10-ton) bridge 11.3-m (37-ft) hook height Room 117 One 27 210-kg (30-ton) bridge 16.8-m (55-ft) hook height | 12.2 m by 18.3 m (40 ft by 60 ft) | 6.1 m by 12.2 m (20 ft by 40 ft) | One 9070-kg (10-ton) bridge 11.3-m (37-ft) hook height | | 4-m dia |
| California Spaceport (IPF) | VAFB | 3 | Class 100,000 High bay: 9.1 m by 44.8 m (3 ft by 147 ft) Payload check-out cells: 10.7 m by 13.4 m (35 ft by 44 ft) payload transfer | High bay: 7.3 m by 8.5 m (24 ft by 28 ft) Payload check-out cells: 6.5 m by 21.3 m (21 ft-2 in. by 70 ft) transfer | Vehicle check-out area: 68 040-kg (75-ton) bridge (proof load to 26 300 kg [29 tons]) 26.3-m (86 ft-4 in.) hook height | Class 100,000 9.1m by 30.5 m (30 ft by 100 ft) | Vehicle check-out facility: 7.3 m by 30.5 m (24 ft by 100 ft) | Two 4535-kg (5-ton) bridges 10.8-m (35 ft-5-in.) hook height | SSI is under contract to design a payload encapsulation facility | No (due to configuration and access issues this facility will not meet minimum encapsulation requirements) |

Facility data based on a variety of sources including interface control drawings (ICDs), facility drawings, and verbal responses to questions. The facility ICD will supersede information contained in this matrix.

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At VAFB, two payload processing facilities exist that are adequate for encapsulation operations with modifications. The facilities capable of supporting encapsulation operations with modification are:

| Facility | Encapsulation capability |
|---|---|
| Astrotech Space Operations (requires modification) | 4-m fairings<br>5-m fairings (with modifications) |
| Integrated Processing Facility (requires modification) | 4-m fairings<br>5-m fairings (with modifications) |

## 7.4 SPACE LAUNCH COMPLEX 6

Space Launch Complex 6 (SLC-6) (Figure 7-25) consists of one launch pad, the Delta Operations Center (DOC), a support equipment building (SEB), a horizontal integration facility (HIF), and other facilities necessary to prepare, service, and launch the Delta IV launch vehicles. A site plan of SLC-6 is shown in Figure 7-26.

Because all operations in the launch complex involve or are conducted in the vicinity of liquid or solid propellants and/or explosive ordnance devices, the number of personnel permitted in the area, safety clothing to be worn, type of activity permitted, and equipment allowed are strictly regulated. Adherence to all safety regulations is required. Briefings on all these subjects are given to those required to work in the launch complex area.

### 7.4.1 Mobile Service Tower

The SLC-6 mobile service tower (MST) (Figure 7-27) provides a 79.2-m (260-ft) hook height with 11 working levels. An elevator provides access to the working levels. The payload area encompasses levels 8 through 12. Platform 8 (Figure 7-28) is the initial level through which all traffic to the upper levels is controlled. Figure 7-28 is a typical layout of all upper levels with a few exceptions. Limited space is available on levels 8 to 12 for spacecraft ground support equipment (GSE).

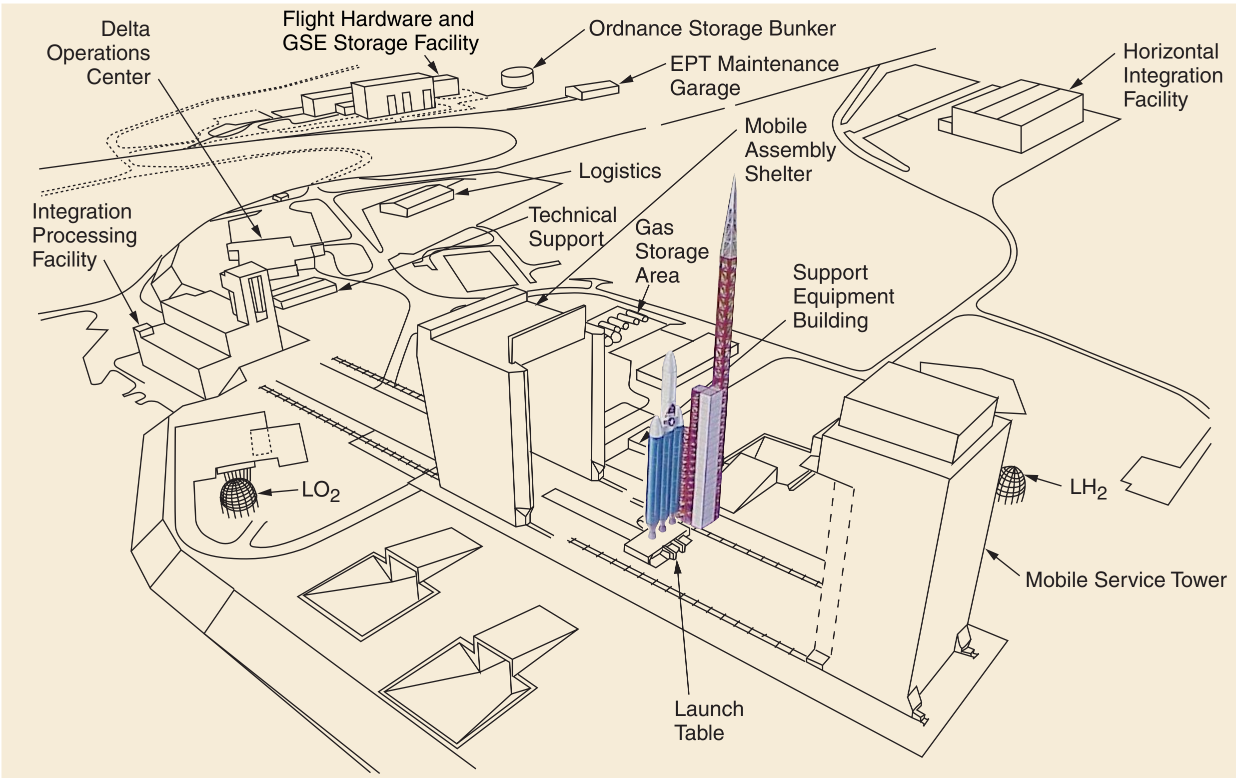


**Figure 7-25. Space Launch Complex 6**

Its placement must be coordinated with Boeing, and appropriate seismic restraints provided by the spacecraft customer.

The entire MST is constructed to meet explosion-proof safety requirements. The restriction on the number of personnel admitted to the payload area is governed by safety requirements, as well as by the limited amount of work space. Cleanroom access to the payload is provided by a portable cleanroom enclosure.

### 7.4.2 Common Support Building

The existing structures (buildings 384 and 392) are used for offices, supply rooms, tool rooms, break rooms, and other like items necessary to support operations at the launch pad. (Refer to Figures 7-29, 7-30 and 7-31 for a floor plan of these facilities.) These structures will not be occupied during launch.

### 7.4.3 Integrated Processing Facility

Payload processing may be accomplished in the facilities currently in use for this function. The payloads for the Delta IV program may also be encapsulated in these facilities. The facilities expected to be used are either the SSI integrated processing facility (IPF) or the commercial Astrotech facility.

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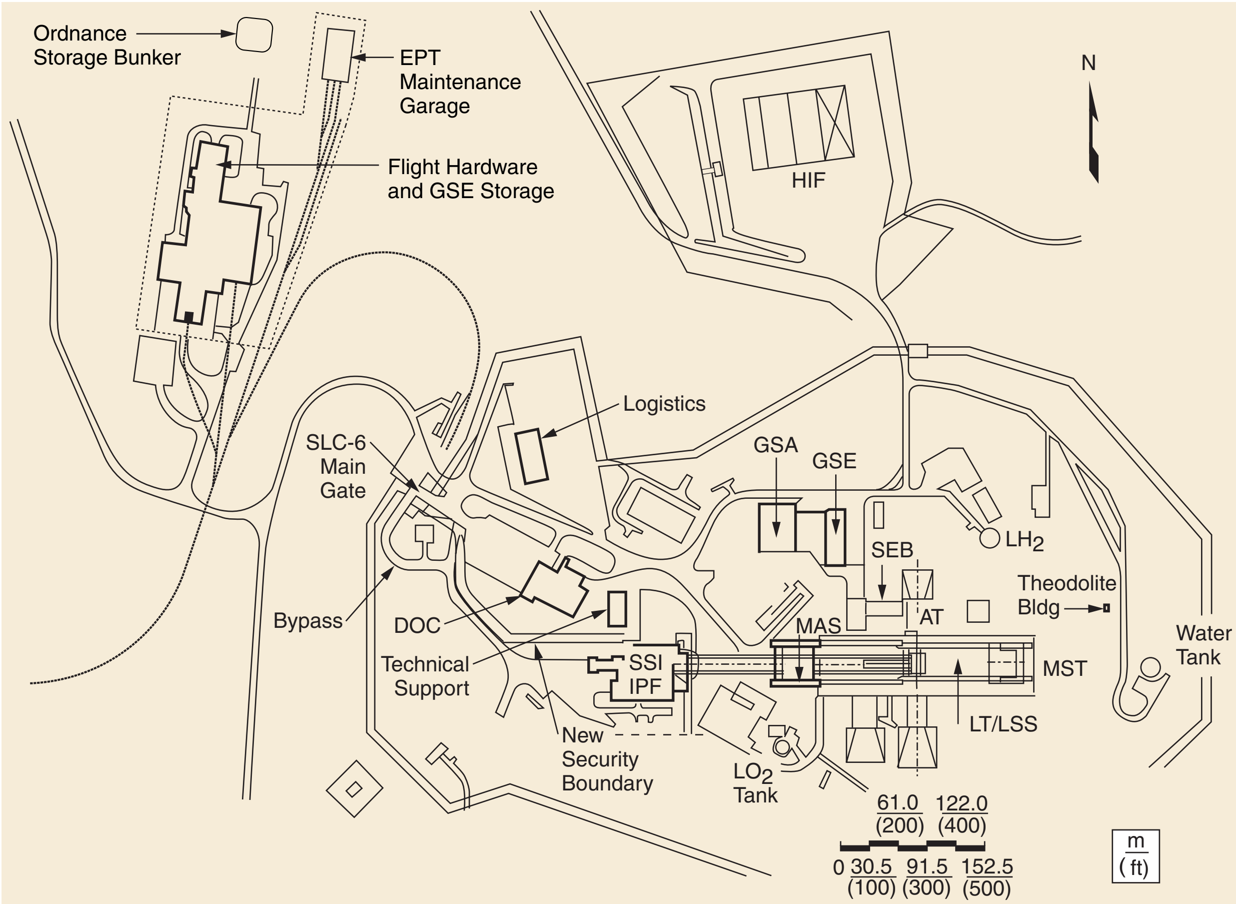


**Figure 7-26. Space Launch Complex 6, VAFB Site Plan**

## 7.4.4 Support Equipment Building

The existing support equipment buildings (SEB) and air-conditioning shelter (facilities 395 and 395A) will be used as the SEB (Figure 7-32.) The SEB will contain the payload air-conditioning equipment and electrical and data communications equipment needed in the near vicinity of the launch vehicle. The SEB will also include personnel support facilities such as toilet and locker rooms, break room/meeting area, and parts storage and tool issue (Figure 7-33). The personnel support facilities are sized to support only the small number of personnel that are expected to be working on the pad at any one time. Space is also allocated for use by payload personnel. A payload console that will accept a standard rack-mounted panel is available. Terminal board connections in the console provide electrical connection to the payload umbilical wires. This structure will not be occupied during launch.

## 7.4.5 Horizontal Integration Facility

Located at the north side of SLC-6 (Figure 7-25), the horizontal integration facility (HIF) is used to receive and process the launch vehicles after their transport from the vessel dock to the facility. Work areas are used for assembly and checkout to provide fully integrated launch vehicles ready for transfer to the launch pad. The HIF will have two bays for four single-core (Delta IV-M and

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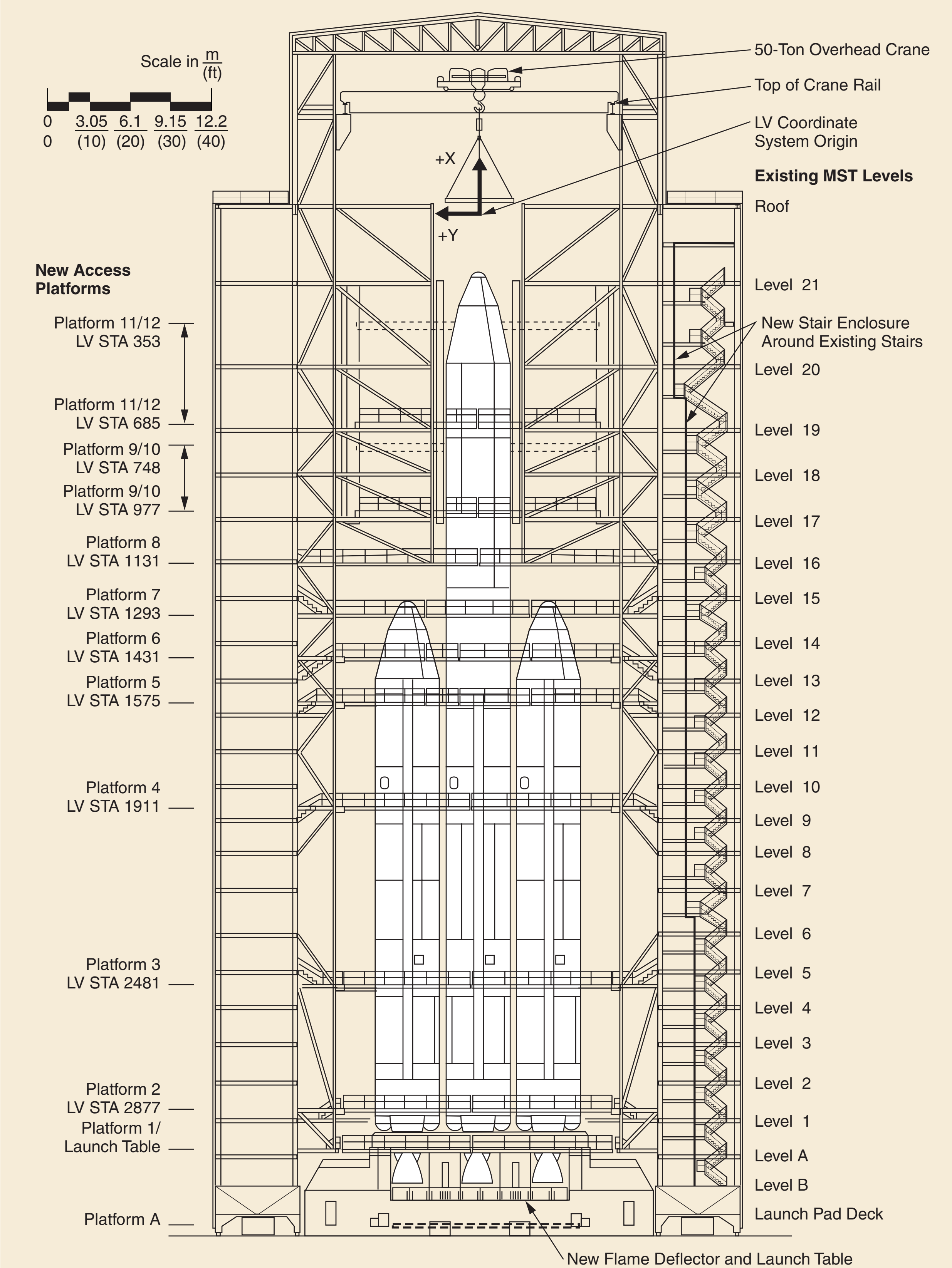


**Figure 7-27. Space Launch Complex 6 MST Elevation**

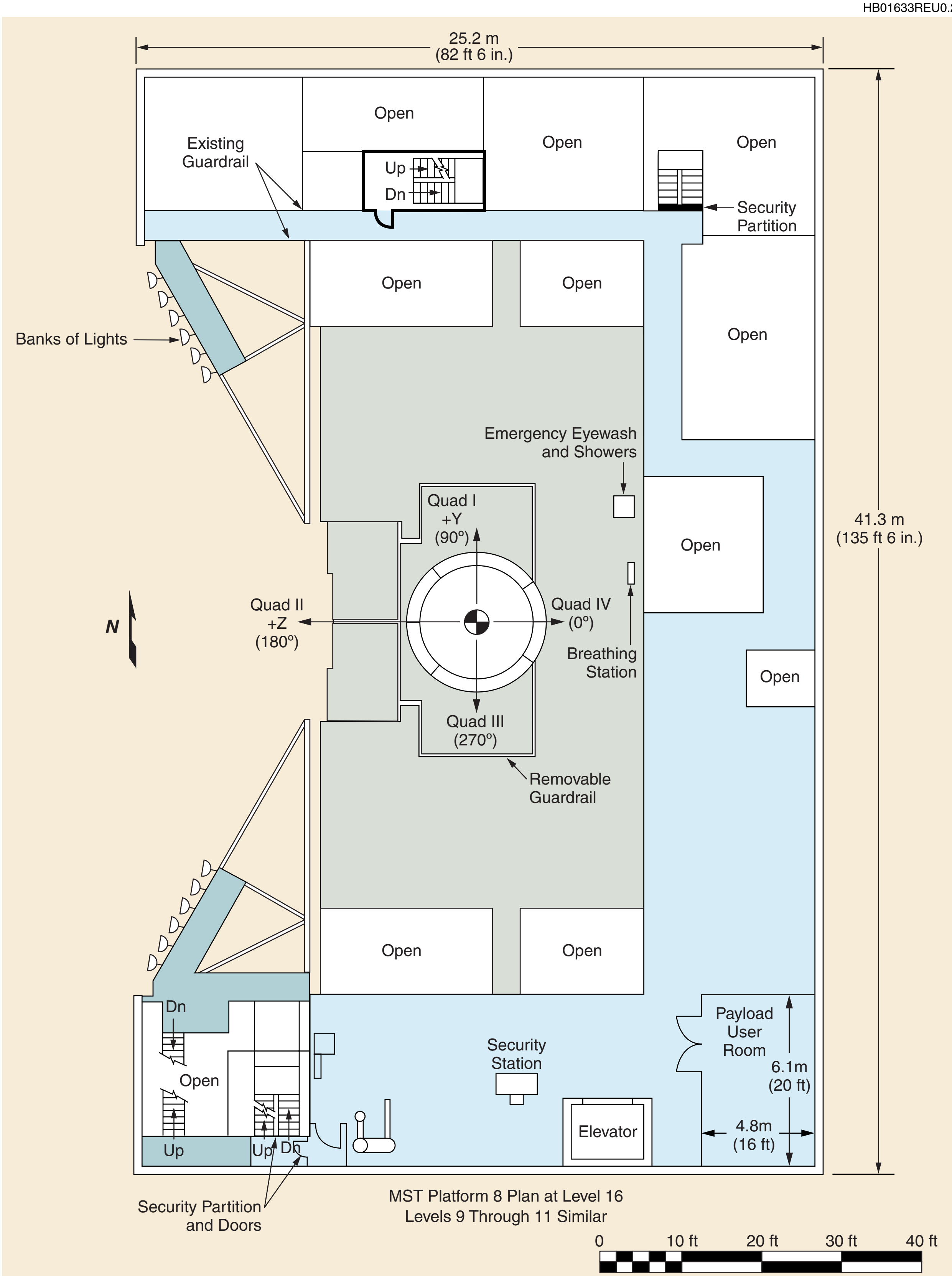


**Figure 7-28. Platform 8 of Space Launch Complex 6 Mobile Service Tower Plan View**

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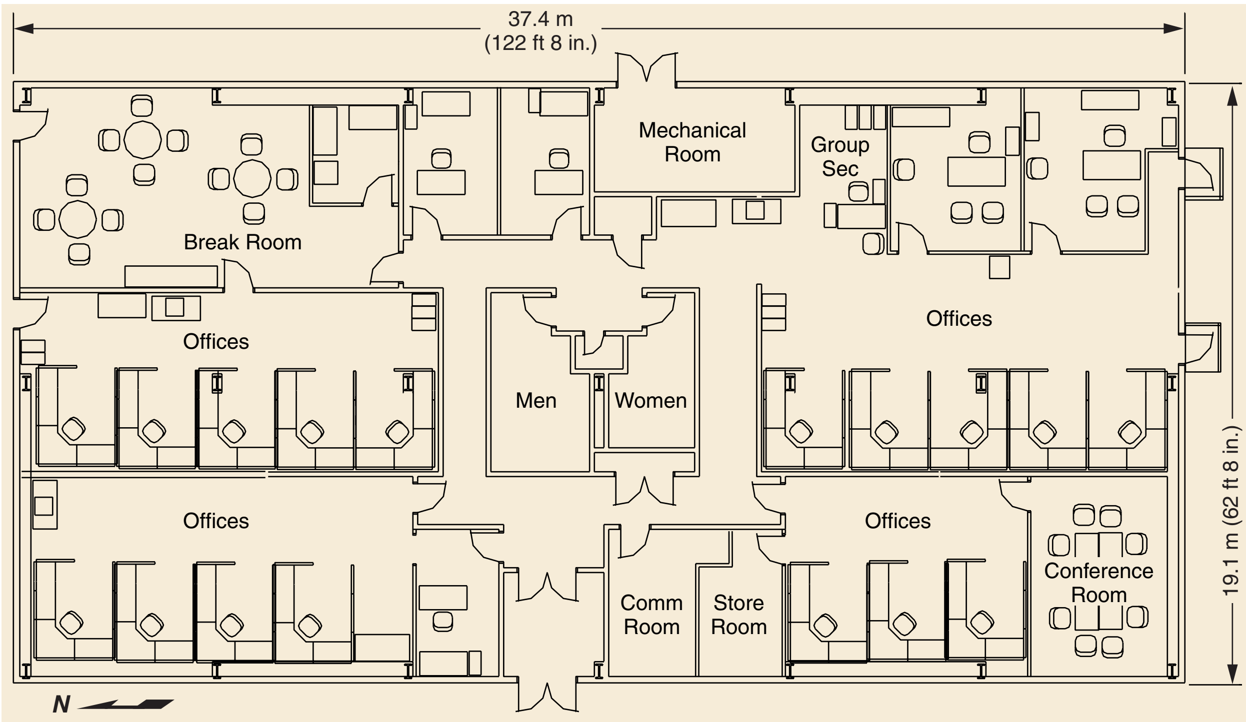


**Figure 7-29. Technical Support (Building 384)**

Delta IV-M+) process areas or two single-core (Delta IV-M and Delta IV-M+) process areas and a Delta IV-H process area (Figures 7-34 and 7-35).

### 7.4.6 Range Operations Control Center

The range operations control center (ROCC) will be used in its current function to control range safety and other range operations. No physical modifications are expected in the ROCC (building 7000) to facilitate support of the Delta IV program. The remote launch control center (RLCC) for SLC-6 will be located in building 8510 on north VAFB. A new RLCC will be constructed using space in the existing building.

The RLCC will be used to conduct launch operations at SLC-6 and will serve as the oversight and range control center for Delta IV operations. Figure 7-2 shows the facility locations at VAFB.

## 7.5 SUPPORT SERVICES

### 7.5.1 Launch Support

For countdown operations, the launch team is located in the RLCC in building 8510 (Figure 7-36), with support from other base organizations.

**7.5.1.1 Mission Director Center (Building 840).** The Mission Director Center (MDC) provides the necessary seating, data display, and communications to observe the launch process. Seating is provided for key personnel from Boeing, the Western Range, and the payload control team.

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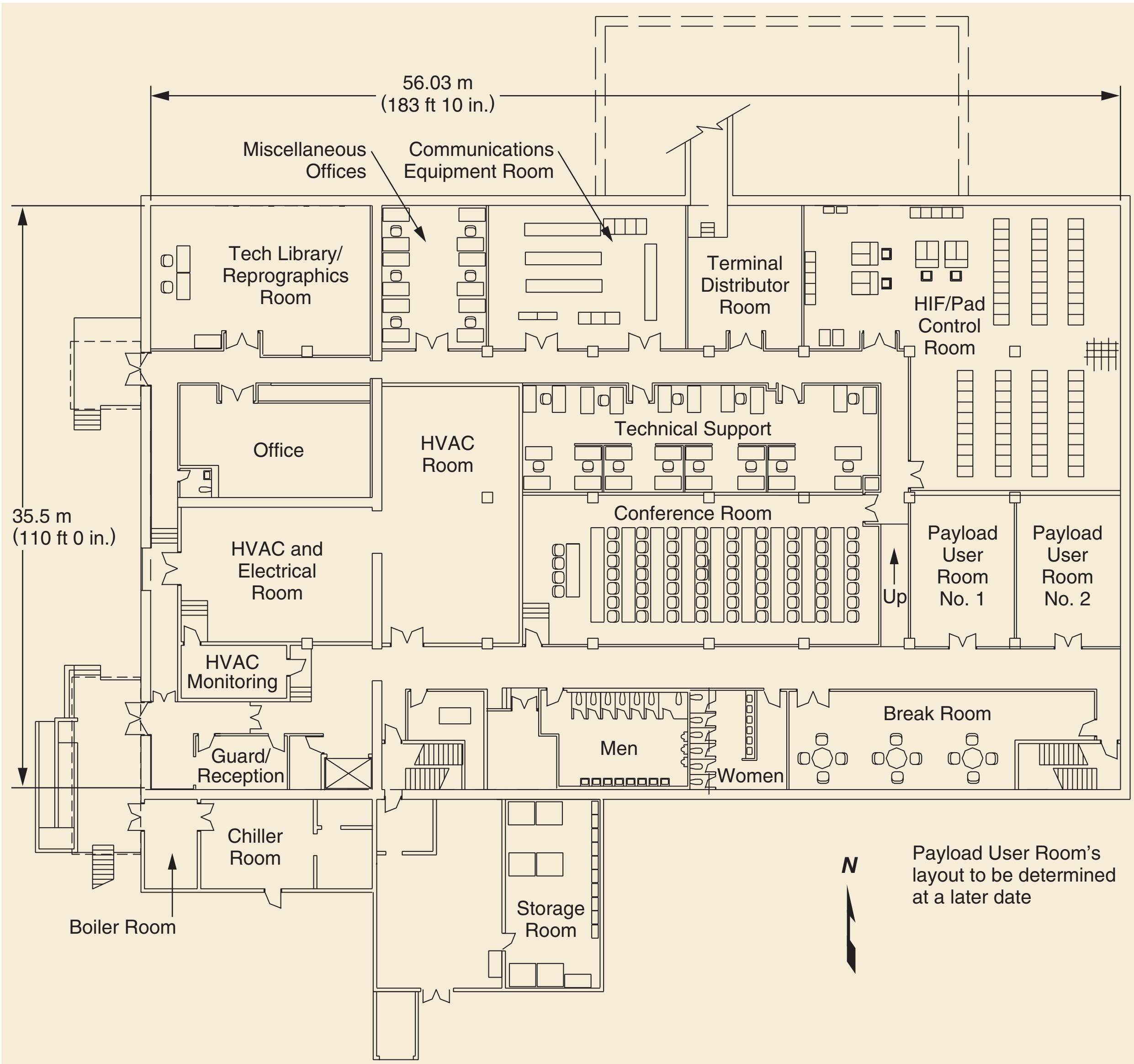


**Figure 7-30. Delta Operations Center First Floor (Building 392)**

**7.5.1.2 Building 8510 Remote Launch Control Center (RLCC).** Launch operations are controlled from the remote launch control center (RLCC) building 8510, located on north base behind building 8500 in a secure area (Figure 7-37). It is equipped with launch vehicle monitoring and control equipment. Space is allocated for the space vehicle RLCC consoles and console operators. Terminal board connections in the payload RLCC junction box provide electrical connection to the payload umbilical cables.

**7.5.1.3 Launch-Decision Process.** The launch-decision process is made by the appropriate management personnel representing the payload, launch vehicle, and range. Figure 7-38 shows the Delta IV communications flow required to make the launch decision.

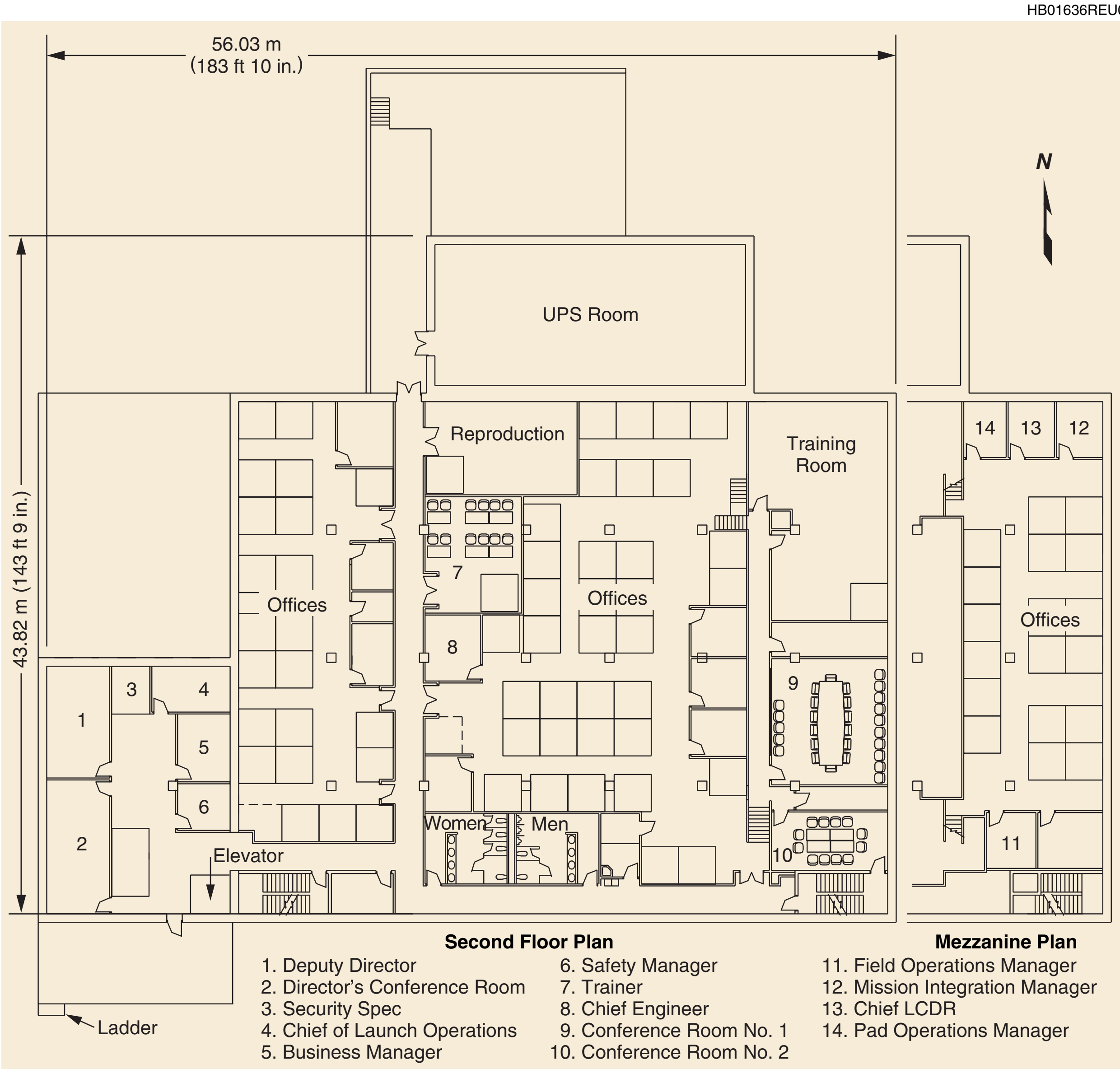


Figure 7-31. Delta Operations Center Second Floor (Building 392)

### 7.5.2 Weather Constraints

**7.5.2.1 Ground-Wind Constraints.** The MST/MAS encloses the Delta IV launch vehicle until approximately T-7 hours and provides protection from ground winds. The winds are measured using an anemometer at the 16.5-m (54-ft) level of the MST.

**7.5.2.2 Winds-Aloft Constraints.** Measurements of winds aloft are taken in the vicinity of the launch pad. The Delta IV launch vehicle controls and load constraints for winds aloft are evaluated on launch day by conducting a trajectory analysis using the measured wind. A curve fit to the wind data provides load relief in the trajectory analysis. The curve fit and other load-relief parameters are used to set the mission constants just prior to launch.

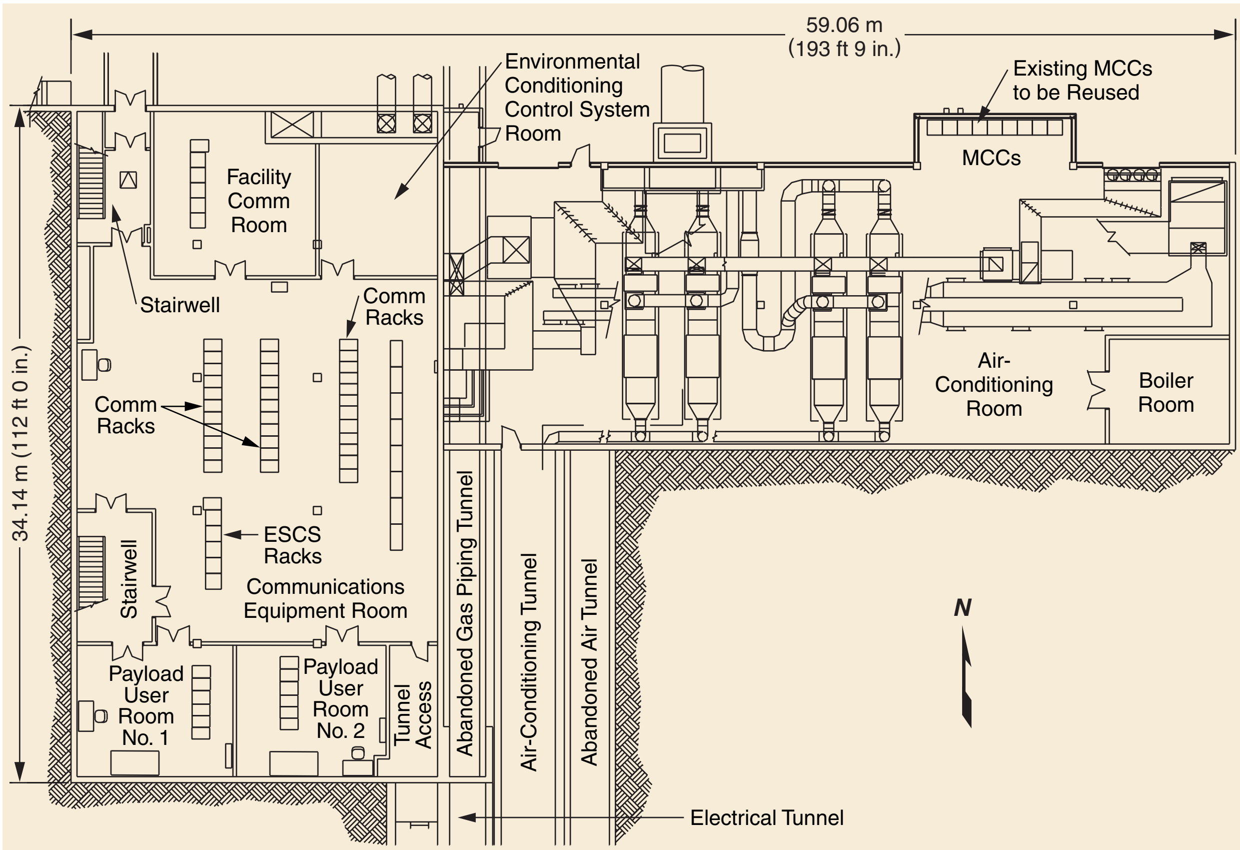


**Figure 7-32. Support Equipment Building (SEB) (Building 395) First-Floor Plan**

**7.5.2.3 Weather Constraints.** Weather constraints are imposed to ensure safe passage of the Delta IV launch vehicle through the atmosphere. The following is a general overview of the constraints evaluated prior to liftoff. Appendix A lists the detailed weather constraints.

A. The launch will not take place if the normal flight path will carry the launch vehicle:

1. Within 18.5 km (10 nmi) of a cumulonimbus (thunderstorm) cloud, whether convective or in layers, where precipitation or virga is observed.

2. Through any cloud, whether convective or in layers, where precipitation or virga is present.

3. Through any frontal or squall-line clouds extending above 3048 m (10,000 ft).

4. Through cloud layers or through cumulus clouds where the freeze level is in the clouds.

5. Through previously electrified clouds not monitored by an electrical field mill network if the dissipating state was short-lived (less than 15 min after observed electrical activity).

B. The launch will not take place if there is precipitation over the launch site or along the flight path.

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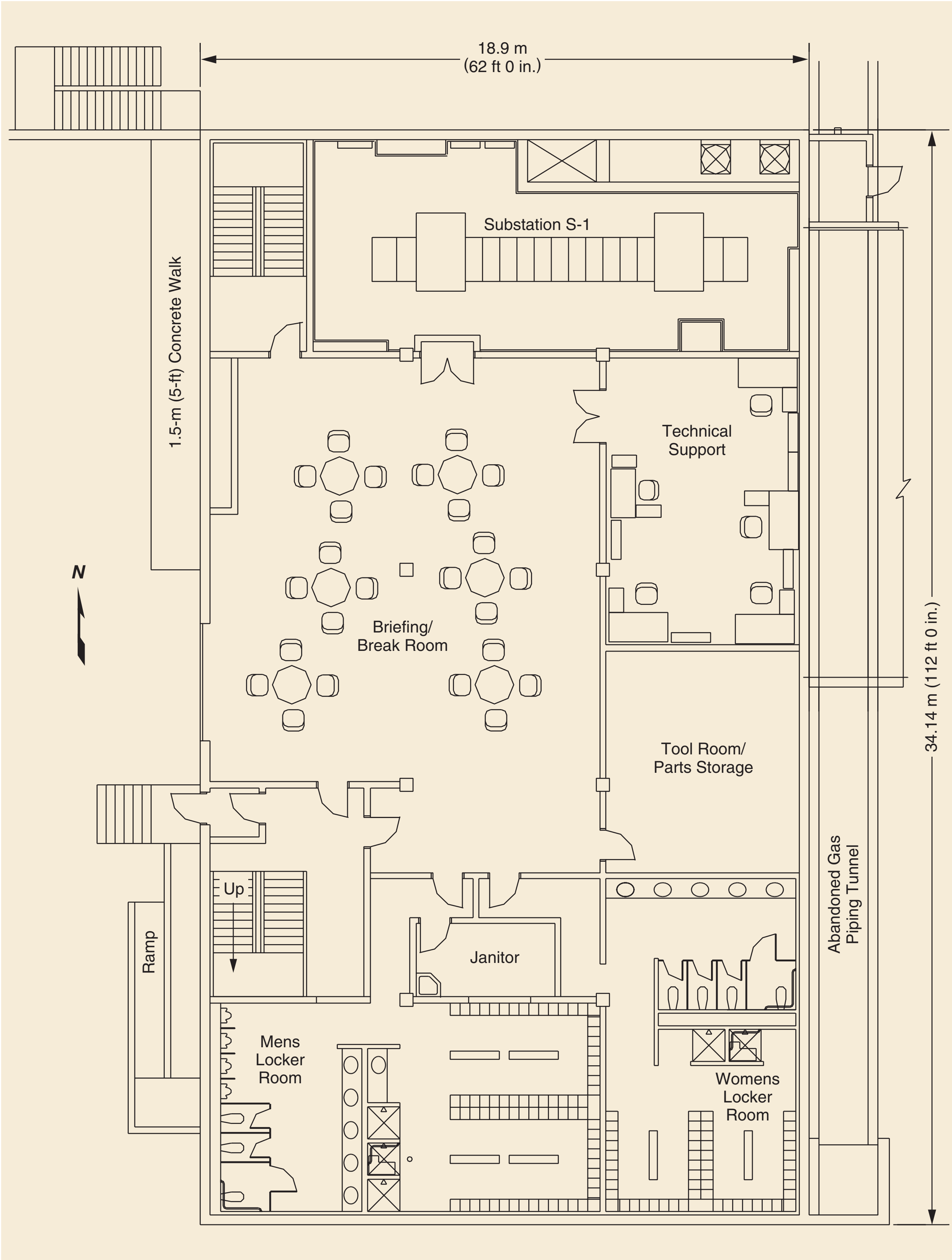


**Figure 7-33. Support Equipment Building (SEB) (Building 395) Second-Floor Plan**

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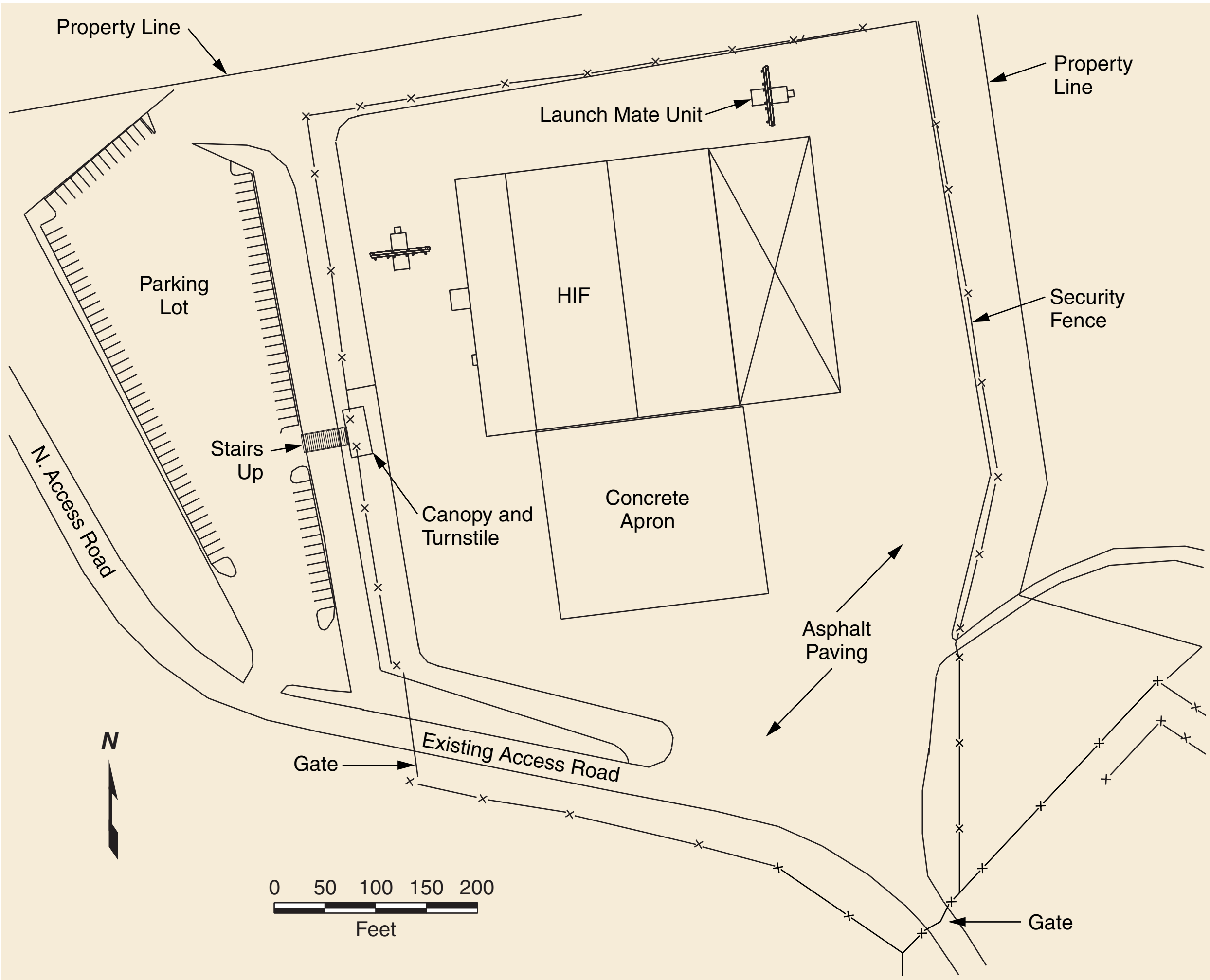


**Figure 7-34. Horizontal Integration Facility (HIF) Site Plan**

C. A weather observation aircraft is mandatory to augment meteorological capabilities for real-time evaluation of local conditions unless a cloud-free line of sight exists to the vehicle flight path. Rawinsonde will not be used to determine cloud buildup.

D. Even though the above criteria are observed or forecast to be satisfied at the predicted launch time, the launch director may elect to delay the launch based on the instability of atmospheric conditions.

**7.5.2.4 Lightning Activities.** The following are procedures for test status during lightning activity:

A. Evacuation of the MST is accomplished at the direction of the Launch Conductor (Reference: Delta Launch Complex Safety Plan).

B. First- and second-stage instrumentation may be operated during an electrical storm.

C. If other launch vehicle electrical systems are powered when an electrical storm approaches, these systems may also remain powered. If Category-A electro-explosive device (EED) circuits

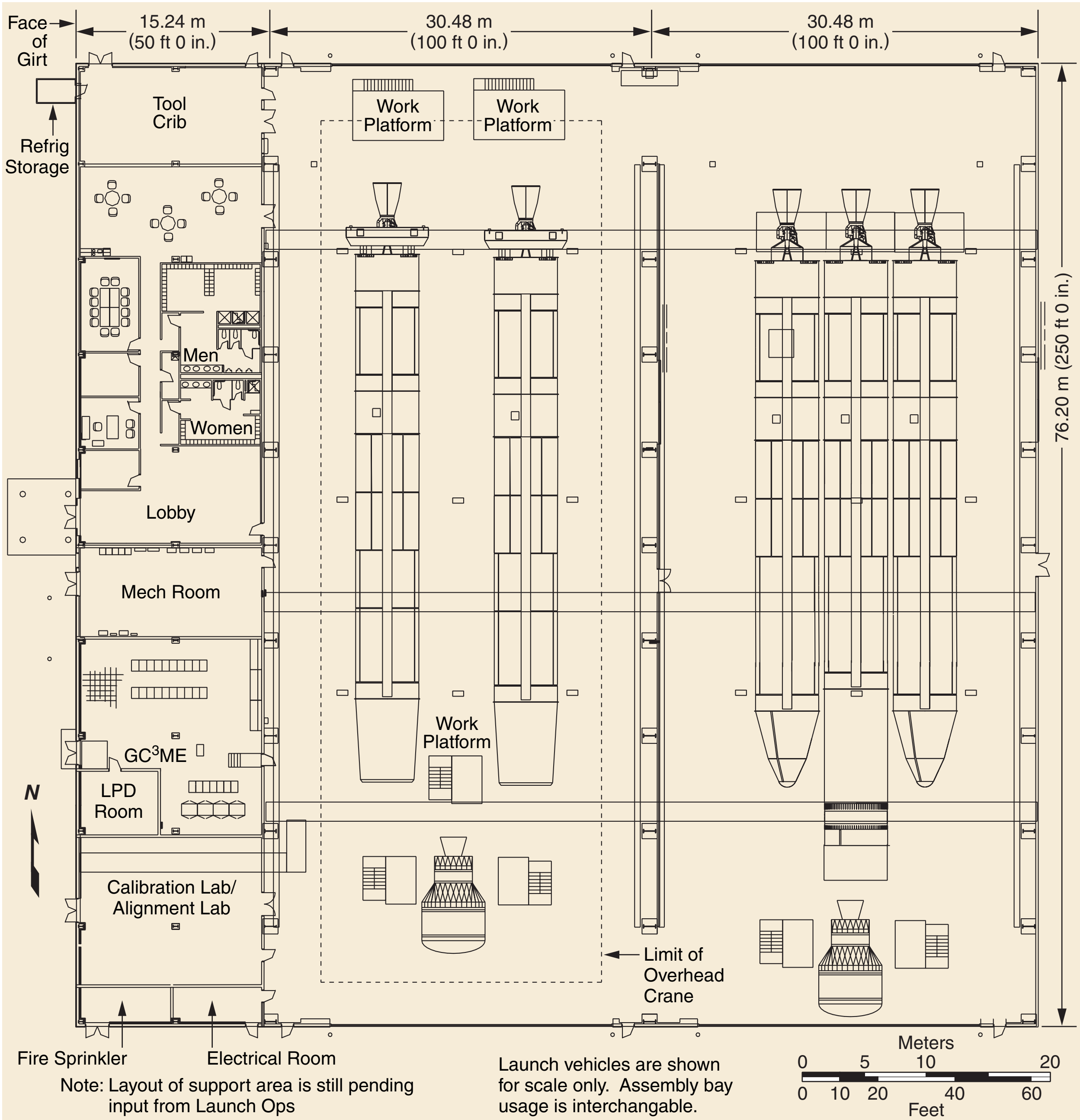


**Figure 7-35. Horizontal Integration Facility (HIF) Floor Plan**

are electrically connected in the launch configurations, the guidance computer (GC) must be turned off.

D. If an electrical storm passes through after launch vehicle automated interface tests, all electrical systems are turned to a quiescent state, and all data sources are evaluated for evidence of damage. This turn-on is done remotely (pad clear) if any Category-A ordnance circuits are connected for flight. Ordnance circuits are disconnected and safed prior to turn-on with personnel exposed to the launch vehicle.

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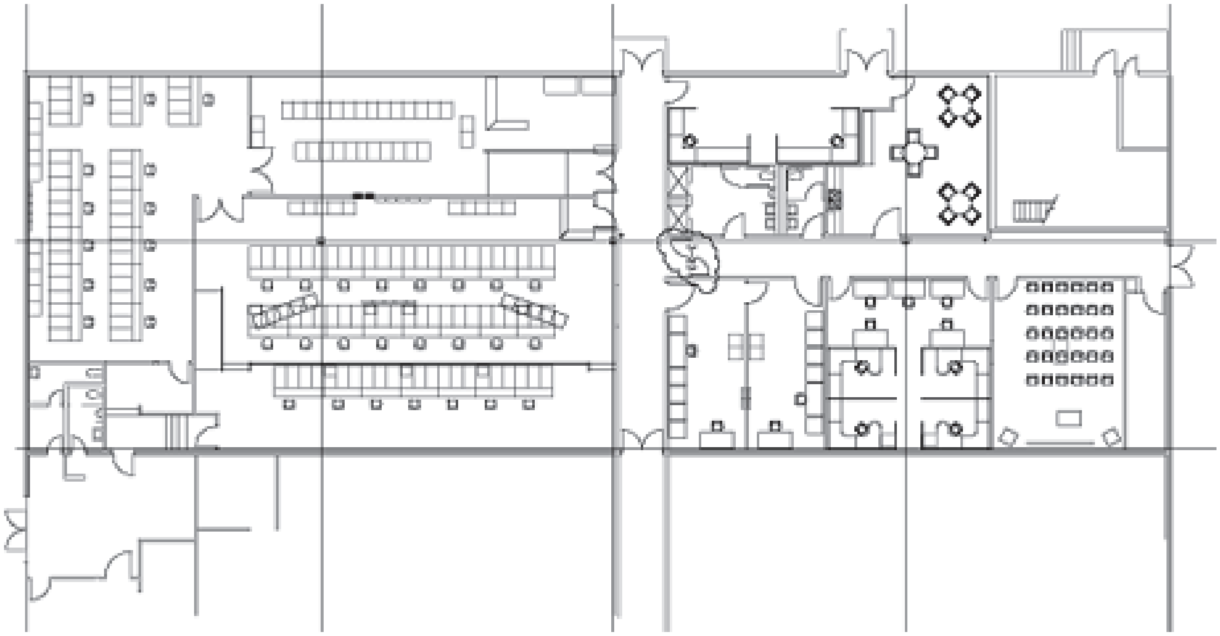

Figure 7-36. VAFB Launch Control Center (Building 8510)

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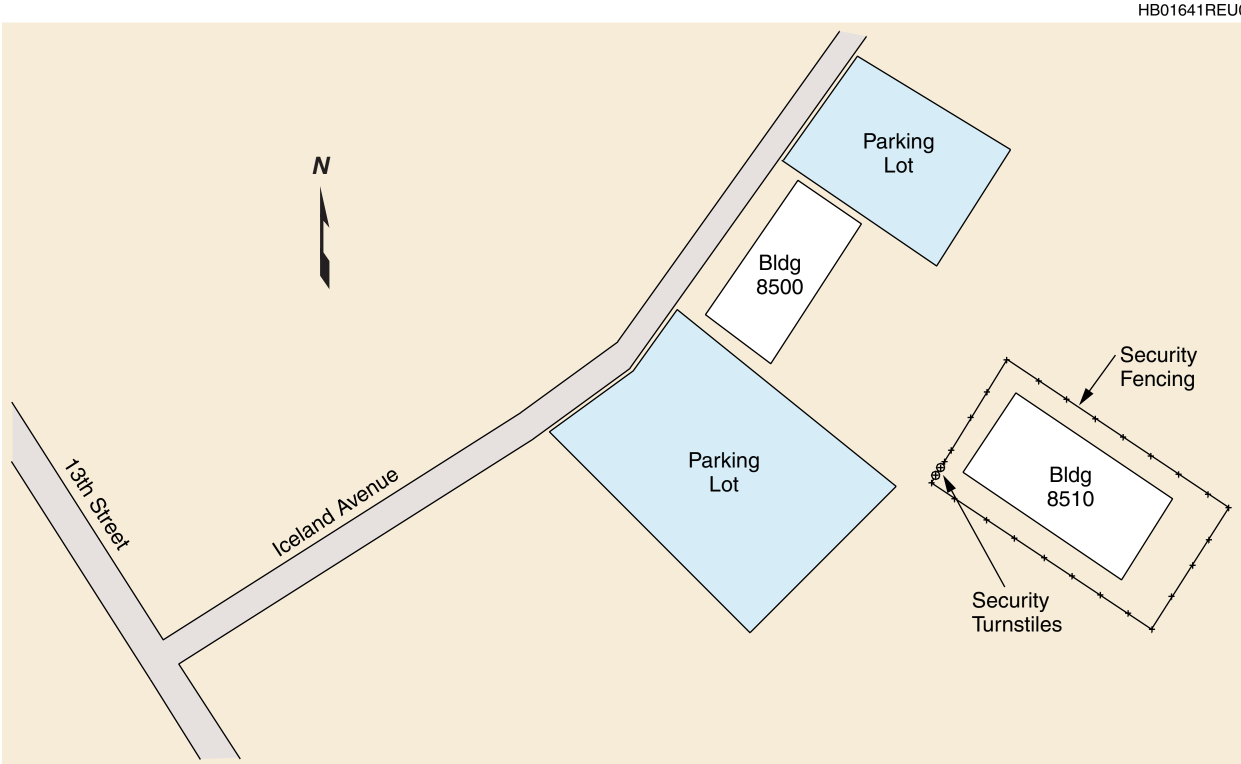


Figure 7-37. Launch Control Center (Building 8510) Site Plan

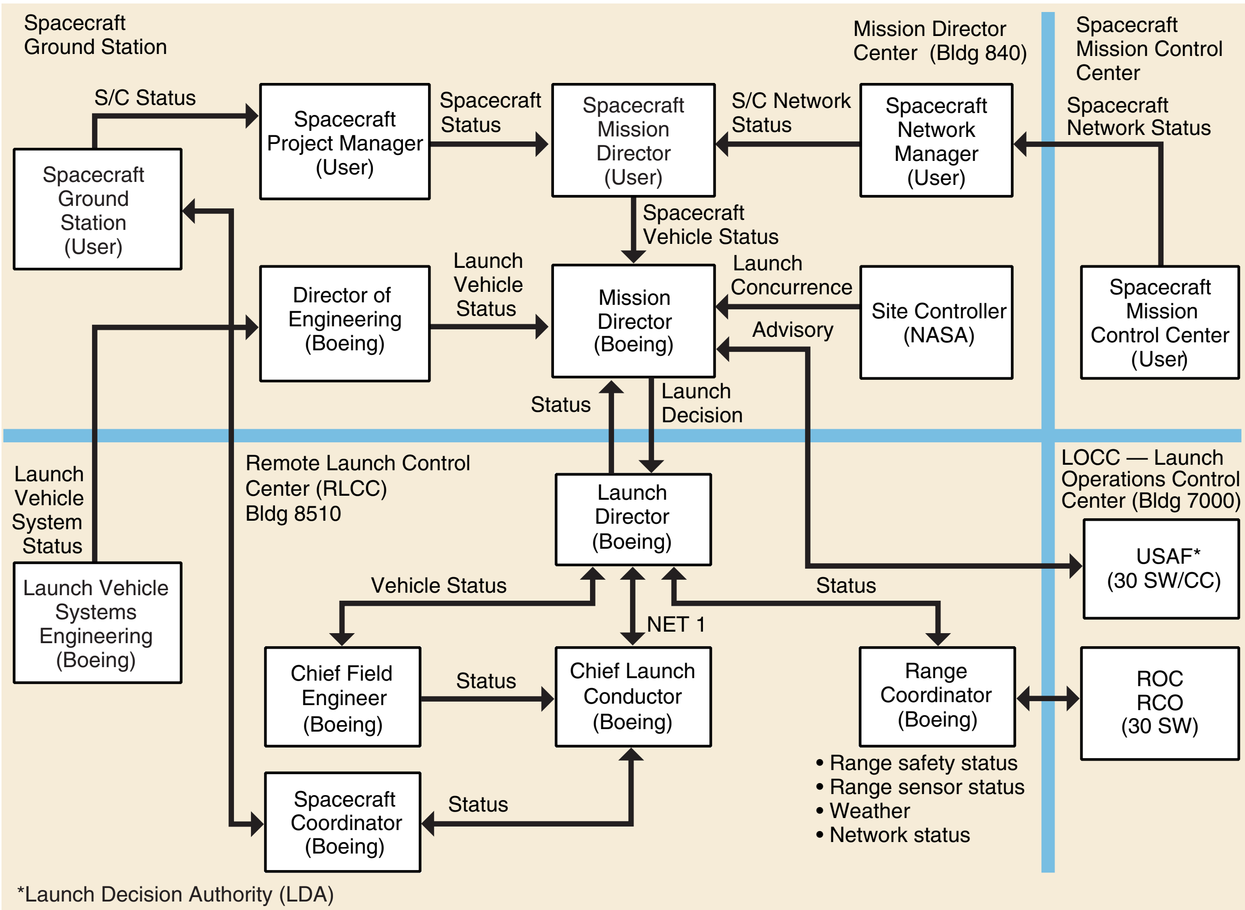


**Figure 7-38. Launch Decision Flow for Commercial Missions—Western Range**

E. If data from the health monitoring reveals equipment discrepancies that can be attributed to the electrical storm, a requalification test must be run subsequent to the storm and prior to a launch attempt.

F. During terminal countdown, the launch director is responsible for initiating and ending an alert. Upon initiation of an alert, the GC is turned off. When the alert is lifted, the GC is turned on and its memory is verified.

### 7.5.3 Operational Safety

Safety requirements are covered in Section 9 of this document. In addition, it is Boeing operating policy that all personnel will be given safety orientation briefings prior to entrance to hazardous areas such as SLC-6. These briefings will be scheduled by the Boeing spacecraft coordinator and presented by appropriate safety personnel.

### 7.5.4 Security

**7.5.4.1 VAFB Security.** For access to VAFB, U.S. citizens must provide to Boeing security NLT 7 days prior to arrival, full name with middle initial (if applicable), company name, company address and telephone number, and dates of arrival and expected departure. Boeing security will arrange for entry authority for commercial missions or individuals sponsored by Boeing. Access by U.S. government-sponsored foreign nationals is coordinated by their sponsor directly with the USAF at VAFB. For non-U.S. citizens, entry authority information (name, nationality/citizenship, date and place of birth, passport number and date/place of issue, visa number and date of expiration, and title or job description and organization, company address, and home address) must be furnished to Boeing security 2 months prior to the VAFB entry date. Government-sponsored individuals must follow U.S. government guidelines as appropriate. After Boeing security obtains entry authority approval, entry to VAFB will be the same as for US citizens.

For security requirements at facilities other than those listed below, please see the appropriate facility user guide.

**7.5.4.2 VAFB Security, Space Launch Complex 6.** SLC-6 security is ensured by perimeter fencing, interior fencing, guards, and access badges. The MST is configured to support security for Priority-A resources.

Unique badging is required for unescorted entry into the fenced area at SLC-6. Arrangements must be made through Boeing security at least 30 days prior to usage, in order to begin badging arrangements for personnel requiring such access. Boeing personnel are also available 24 hr a day to provide escort to others requiring access.

**7.5.4.3 Spacecraft Processing Laboratories.** Physical security at the payload processing laboratories (building 836) is provided by door locks and guards. Details of the payload security requirements are arranged through the Boeing spacecraft coordinator or appropriate payload processing facility.

### 7.5.5 Field-Related Services

Boeing employs certified propellant handlers wearing propellant handler's ensemble (PHE) suits, equipment drivers, welders, riggers, and explosive-ordnance handlers, in addition to personnel experienced in most electrical and mechanical assembly skills such as torquing, soldering, crimping, precision cleaning, and contamination control. Boeing has access to a machine shop, metrology laboratory, $LO_2$ cleaning facility, and proof-loading facility. Boeing operational team members are familiar with USAF, NASA, and commercial payload processing facilities at VAFB and can offer all of these skills and services to the payload project during the launch program.

## 7.6 DELTA IV PLANS AND SCHEDULES

### 7.6.1 Mission Plan

For each launch campaign, a mission plan is developed showing major tasks in a weekly timeline format. The plan includes launch vehicle activities, prelaunch reviews, and payload PPF occupancy times.

### 7.6.2 Integrated Schedules

The schedule of payload activities occurring before integrated activities varies from mission to mission. The extent of payload field testing varies and is determined by the payload contractor.

Payload/launch vehicle schedules are similar from mission to mission from the time of payload weighing (if required) until launch.

Daily schedules are prepared on hourly timelines for these integrated activities. Daily schedules will typically cover the encapsulation effort in the PPF and all days-of-launch countdown activities. PPF tasks include payload weighing, if required, spacecraft-to-PAF mate and interface verification, and fairing encapsulation of the payload. Figures 7-39, 7-40, 7-41, 7-42, 7-43, and 7-44 show the

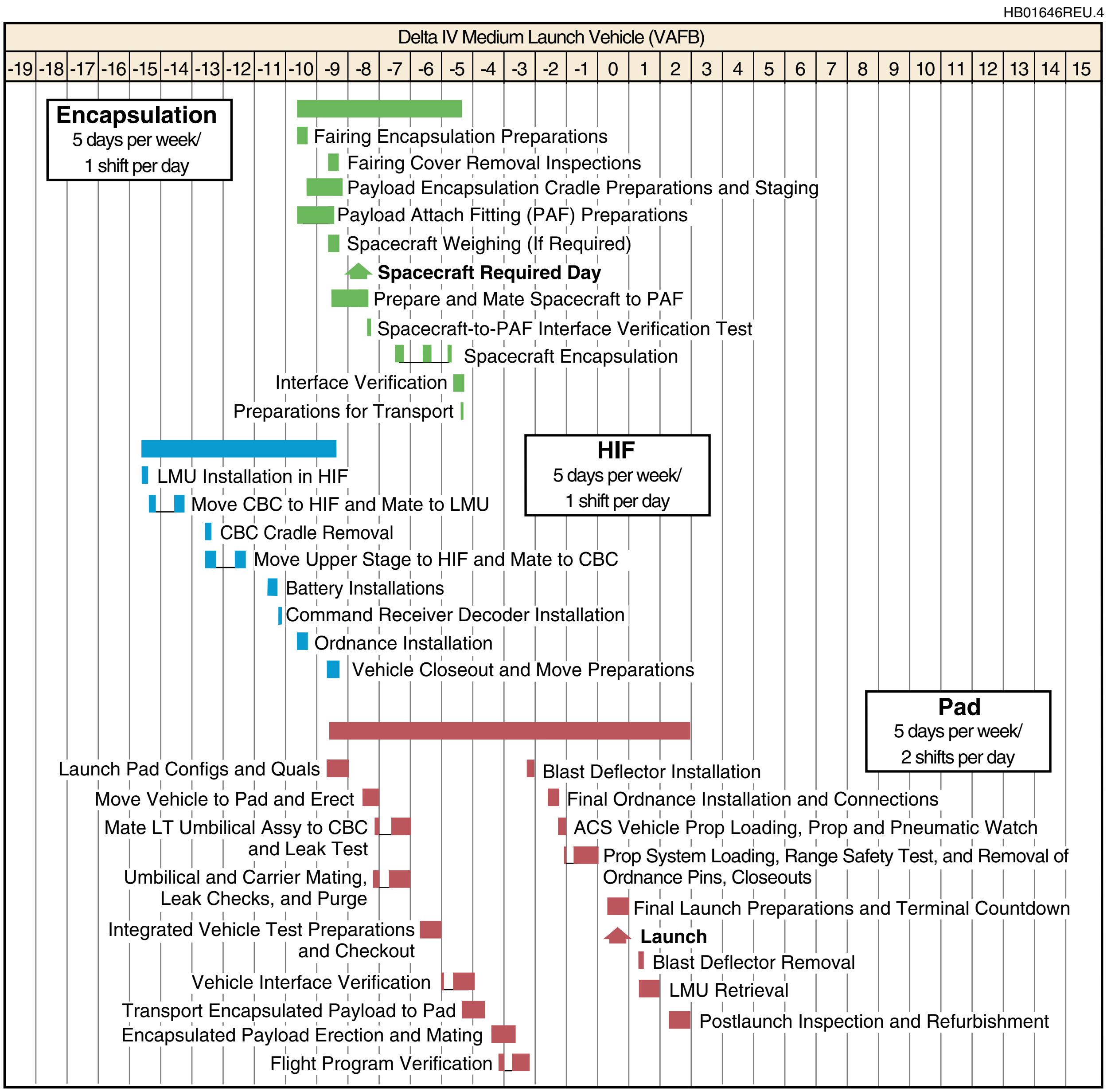


**Figure 7-39. Projected Processing Timeline—Delta IV Medium Launch Vehicle (rev. L)**

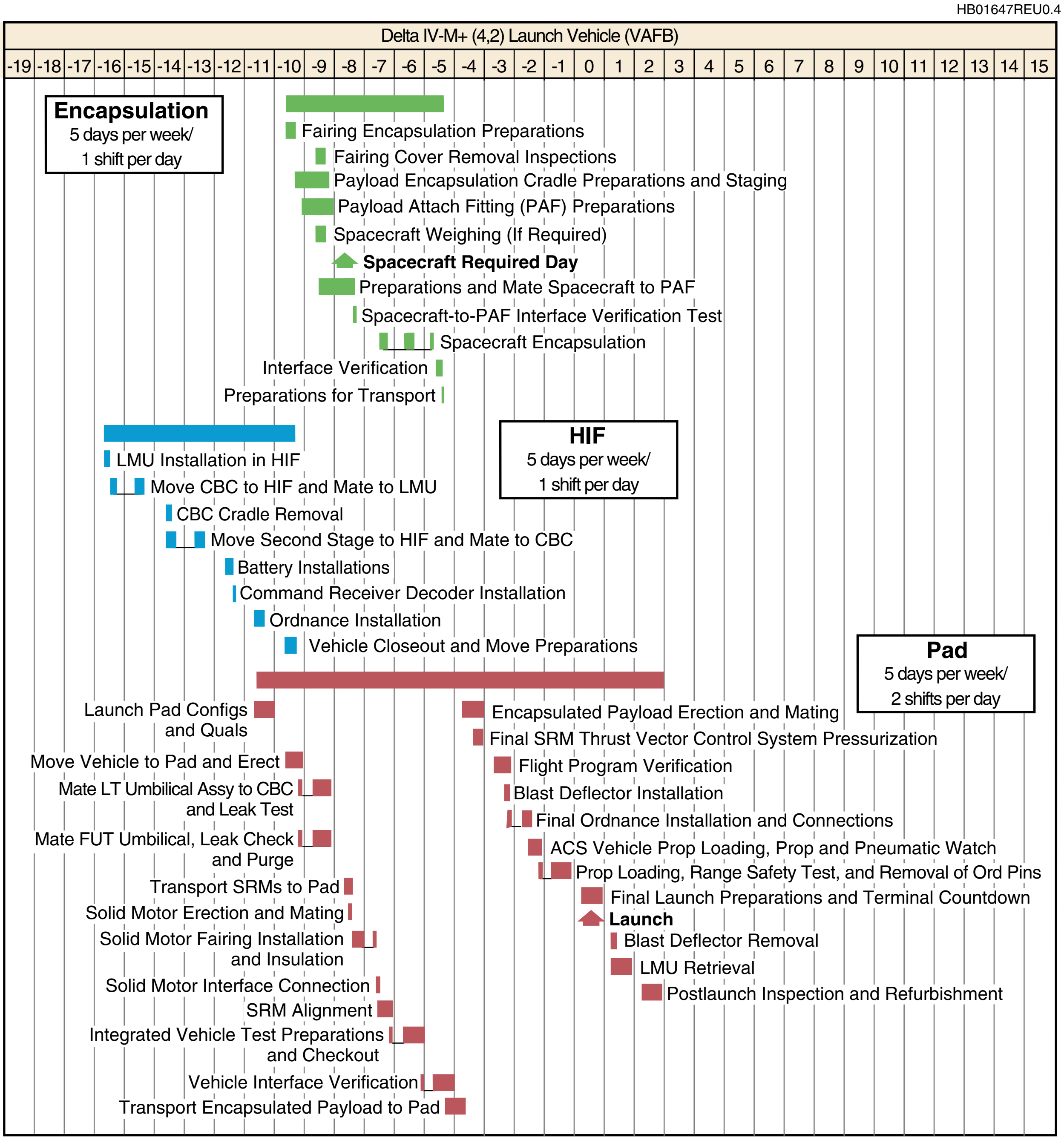


**Figure 7-40. Projected Processing Timeline—Delta IV Medium-Plus (4,2) Launch Vehicle (rev. L)**

processing time lines for Delta IV-M, Delta IV-M+ (4,2), Delta IV-M+ (5,2), Delta IV-M+ (5,4), Delta IV-H composite fairing, and Delta IV-H dual manifest, respectively.

The countdown schedules provide detailed hour-by-hour breakdowns of launch pad operations, illustrating the flow of activities from payload erection through terminal countdown, and reflecting inputs from the spacecraft contractor. These schedules comprise the integrating document to ensure timely launch pad operations.

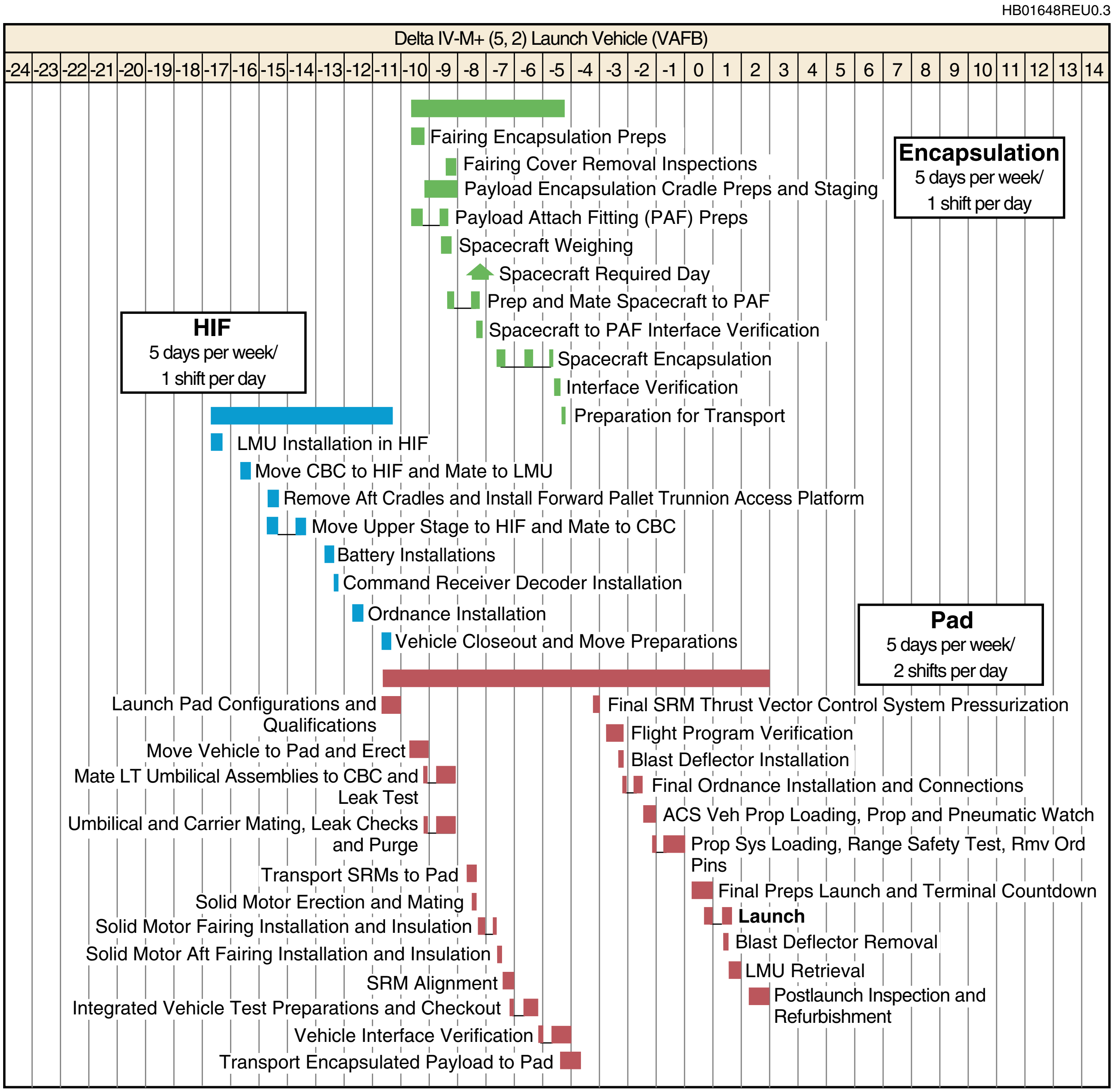


**Figure 7-41. Projected Processing Timeline—Delta IV Medium-Plus (5,2) Launch Vehicle (rev. M)**

The integrated processing time lines do not normally include Saturdays, Sundays, or holidays. The schedules, from payload mate through launch, are coordinated with each customer to optimize on-pad testing. All operations are formally conducted and controlled using launch countdown documents. The schedule of payload activities during that time is controlled by the Boeing launch operations manager.

### 7.6.3 Spacecraft Schedules

The customer will supply schedules to the Boeing spacecraft coordinator, who will arrange support as required.

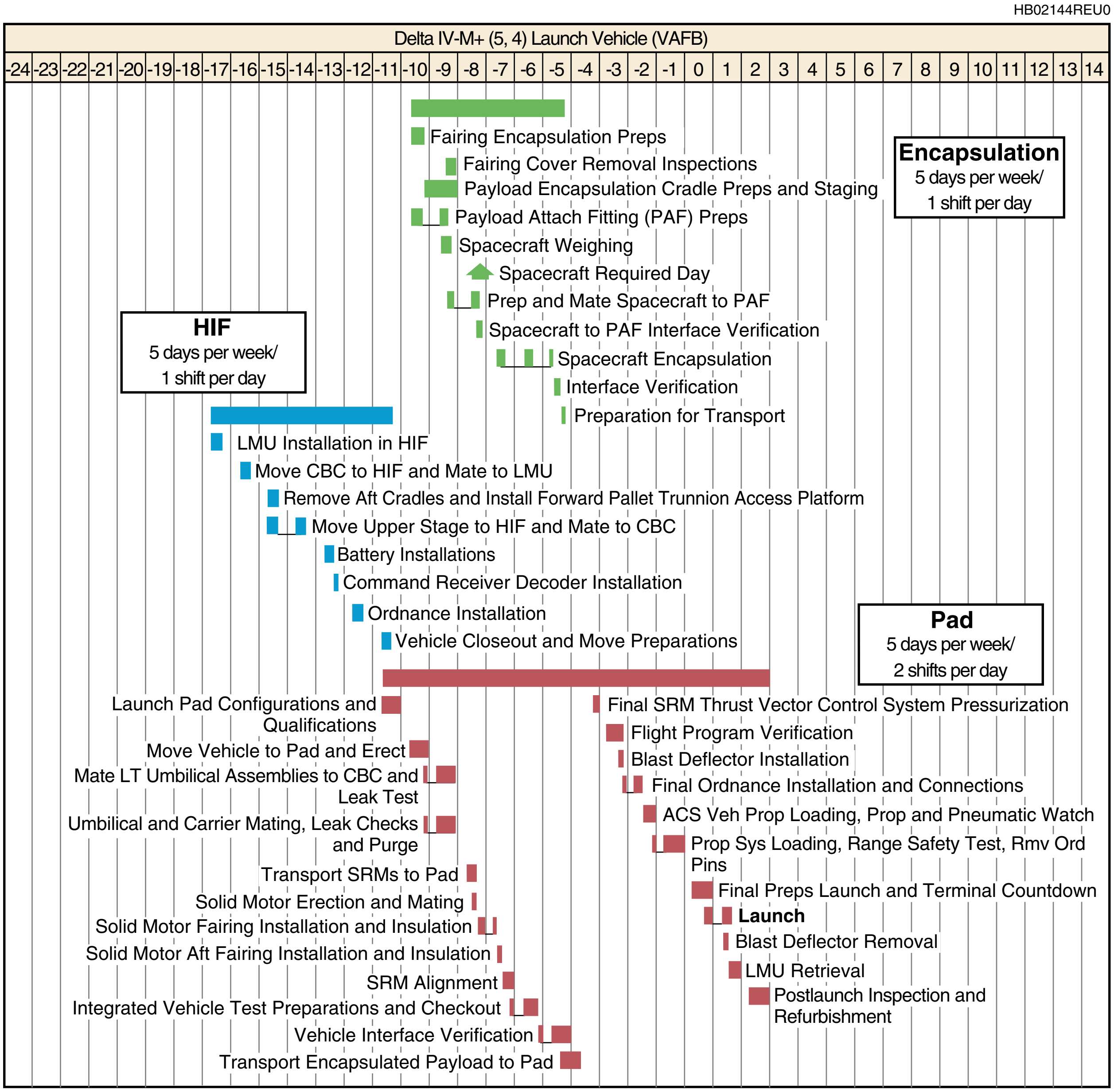


**Figure 7-42. Projected Processing Timeline—Delta IV Medium-Plus (5,4) Launch Vehicle (rev. M)**

## 7.7 DELTA IV MEETINGS AND REVIEWS

During the launch scheduling preparation, various meetings and reviews occur. Some of these will require customer input while others allow the customer to monitor the progress of the overall mission. The Boeing mission integration manager will ensure adequate customer participation.

### 7.7.1 Meetings

Delta status meetings are generally held twice a week. They include a review of the activities scheduled and accomplished since the last meeting, a discussion of problems and their solutions, and a review of the mission schedule. Customers are encouraged to attend these meetings.

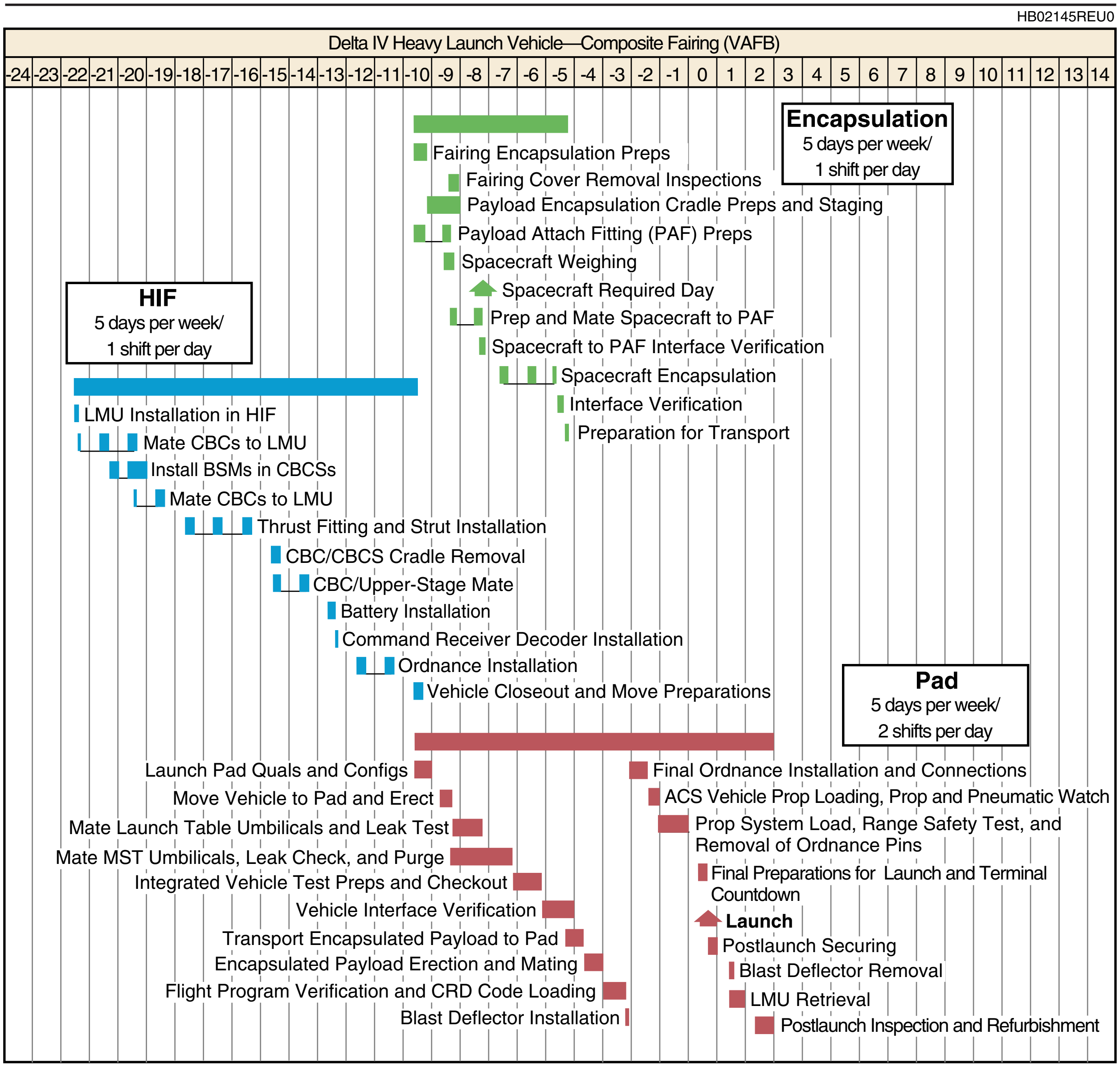


**Figure 7-43. Projected Processing Timeline—Delta IV Heavy Launch Vehicle Composite Fairing (rev. L1)**

Daily schedule meetings are held to provide team members with their assignments and to summarize the previous or current day's accomplishments. These meetings are attended by the launch conductor, technicians, inspectors, engineers, supervisors, and the spacecraft coordinator. Depending on testing activities, these meetings are held at either the beginning or the end of the first shift.

### 7.7.2 Prelaunch Review Process

Periodic reviews are held to ensure that the payload and launch vehicle are ready for launch. The mission plan shows the relationship of the review to the program assembly and test flow.

The following paragraphs discuss the Delta IV readiness reviews.

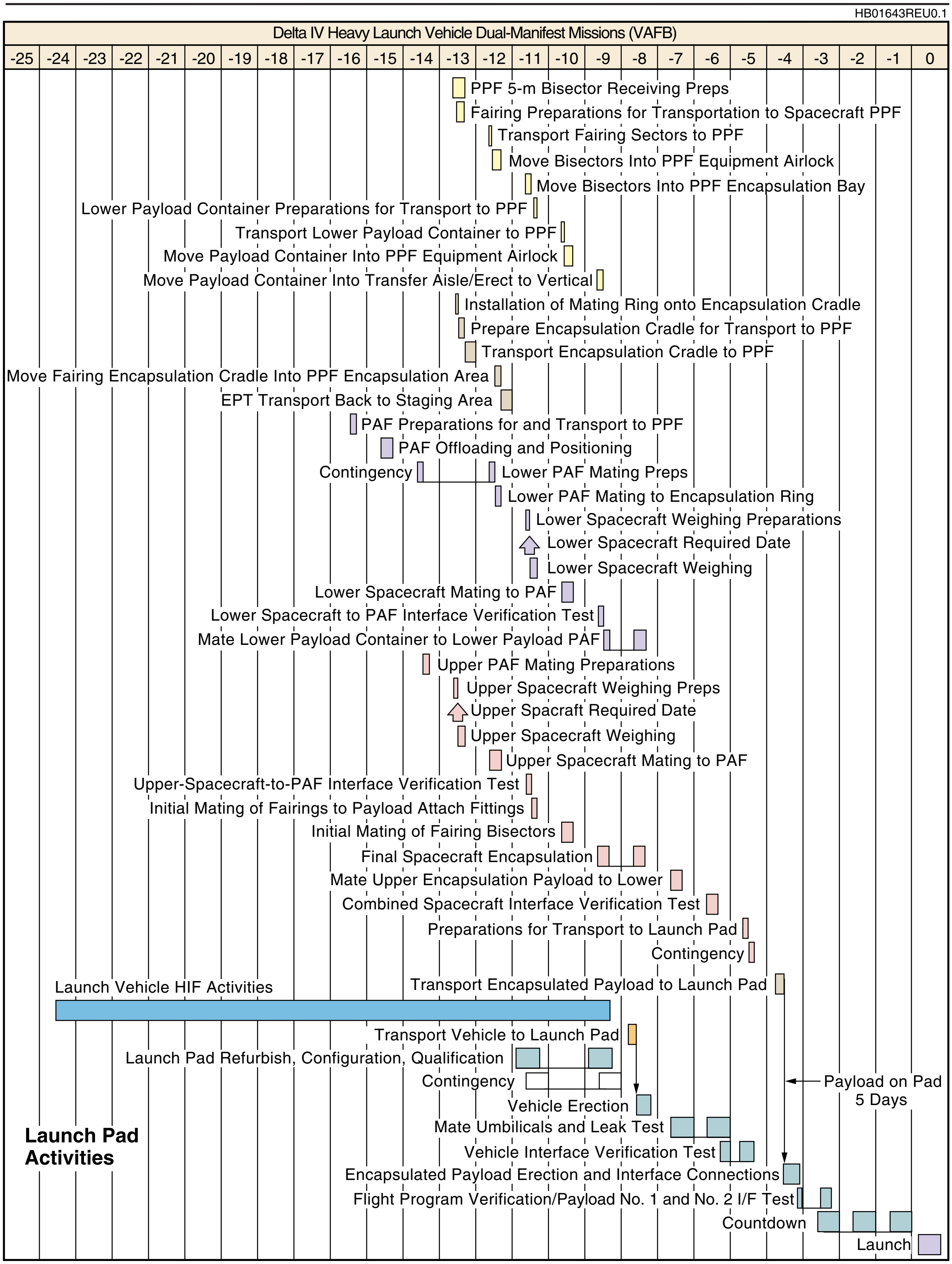


**Figure 7-44. Projected Processing Timeline for Delta IV Heavy Launch Vehicle Dual-Manifest Missions (Preliminary)**

**7.7.2.1 Postproduction Review.** A postproduction meeting is conducted at Decatur, Alabama, to review the flight hardware at the end of production and prior to shipment to VAFB.

**7.7.2.2 Mission Analysis Review.** A mission analysis review is held at Huntington Beach, California, approximately 3 months prior to launch to review mission-specific drawings, studies, and analyses.

**7.7.2.3 Pre-Vehicle-On-Stand Review.** A pre-vehicle-on-stand (Pre-VOS) review is held at VAFB subsequent to the completion of HIF processing and prior to erection of the launch vehicle on the launch pad. It includes an update of the activities since manufacturing, the results of the HIF processing, and any hardware history changes. Launch facility readiness is also discussed. (Pre-VOS occurs approximately at T-12 days.)

**7.7.2.4 Flight Readiness Review.** A flight readiness review (FRR) is a status of the launch vehicle after HIF processing and a mission analysis update. It is conducted to ensure that the launch vehicle and space vehicle are ready for countdown and launch. Upon completion of this meeting, authorization to proceed with the final phases of countdown preparation is given. This review also assesses the readiness of the range to support launch, and provides a predicted weather status (FRR occurs at T-2 days).

**7.7.2.5 Launch Readiness Review.** Launch readiness review (LRR) is held on T-1 day. All agencies and contractors are required to provide a ready-to-launch statement. Upon completion of this meeting, authorization to enter terminal countdown is given.

# Section 8
# PAYLOAD INTEGRATION

This section describes the payload integration process, the supporting documentation required from the spacecraft customer, and the resulting analyses provided by The Boeing Company.

## 8.1 INTEGRATION PROCESS

The integration process (Figure 8-1) developed by Boeing is designed to support the requirements of the launch vehicle and the payload. The tasks below the line are completed by the customer and those above by Boeing. Boeing works closely with customers to tailor the integration flow to meet their individual program requirements. The typical integration process (Figure 8-1) encompasses the entire life of launch vehicle/payload integration activities; L-date is defined as calendar day, including workdays and scheduled non-workdays such as holidays. At its core is a streamlined series of documents, reports, and meetings that are flexible and adaptable to the specific requirements of each program.

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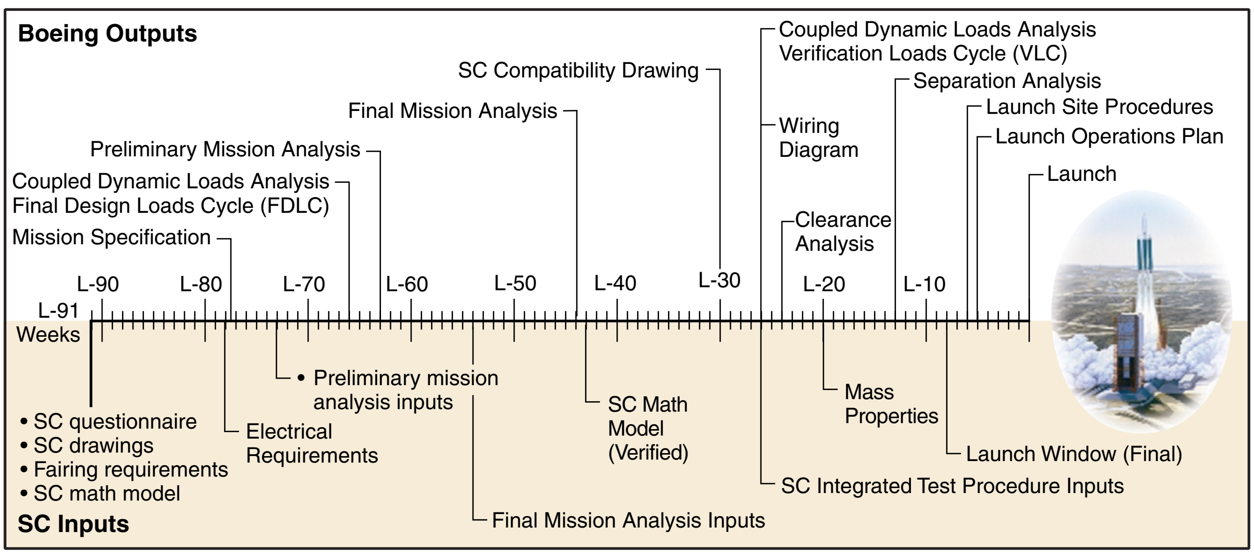


**Figure 8-1. Typical Mission Integration Process**

Mission integration for commercial and government missions is the responsibility of the Delta Program Office located at the Boeing facility in Huntington Beach, California. The objective of mission integration is to coordinate all interface activities required for the launch, including reaching a customer-Boeing interface agreement and accomplishing interface planning, coordinating, scheduling, control, and targeting.

The Delta Program Office assigns a mission integration manager to work with the customer and coordinate all mission-related interface activities. The mission integration manager develops a tailored integration planning schedule for both the launch vehicle and the payload by defining the documentation and analysis required. The mission integration manager also synthesizes payload requirements, engineering design, and launch environments into a controlled mission specification that establishes and documents all agreed-to interface requirements.

The mission integration manager ensures that all lines of communication function effectively. To this end, all pertinent communications, including technical/administrative documentation, technical interchange meetings (TIM), and formal integration meetings are coordinated through the mission integration manager and executed in a timely manner. These data-exchange lines exist not only between the customer and Boeing, but also include other agencies involved in the Delta IV launch. Figure 8-2 illustrates the relationships among agencies involved in a typical Delta IV mission.

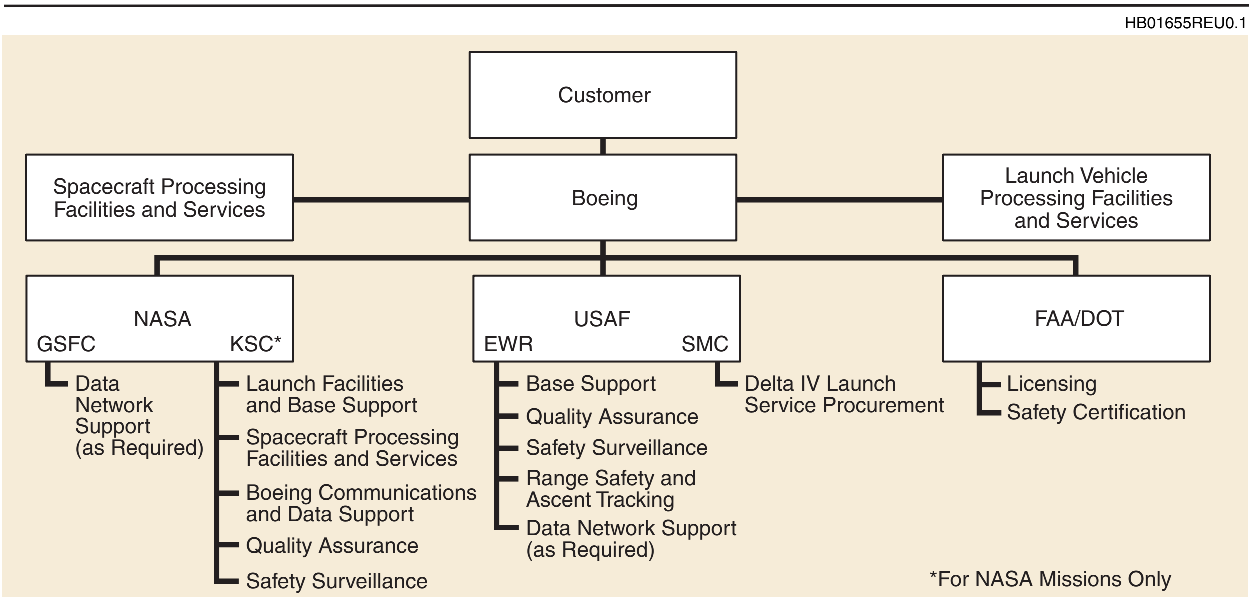


**Figure 8-2. Typical Delta IV Agency Interfaces**

## 8.2 DOCUMENTATION

Effective integration of the payload into the Delta IV launch system requires diligent, timely preparation and submittal of required documents. When submitted, these documents represent the primary communication of requirements, safety provisions, and system descriptions to each of the launch support agencies. The Delta Program Office acts as the administrative interface to assure proper documentation has been provided to the appropriate agencies. All formal and informal data are routed through this office. Relationships of the various categories of documentation are shown in Figure 8-3.

A typical integration planning schedule is shown in Figure 8-4. Each data item listed in Figure 8-4 has an associated L-date (weeks before launch). The party responsible for each data item is identified. Close coordination with the Delta IV mission integration manager is required to achieve successful planning of integration documentation.

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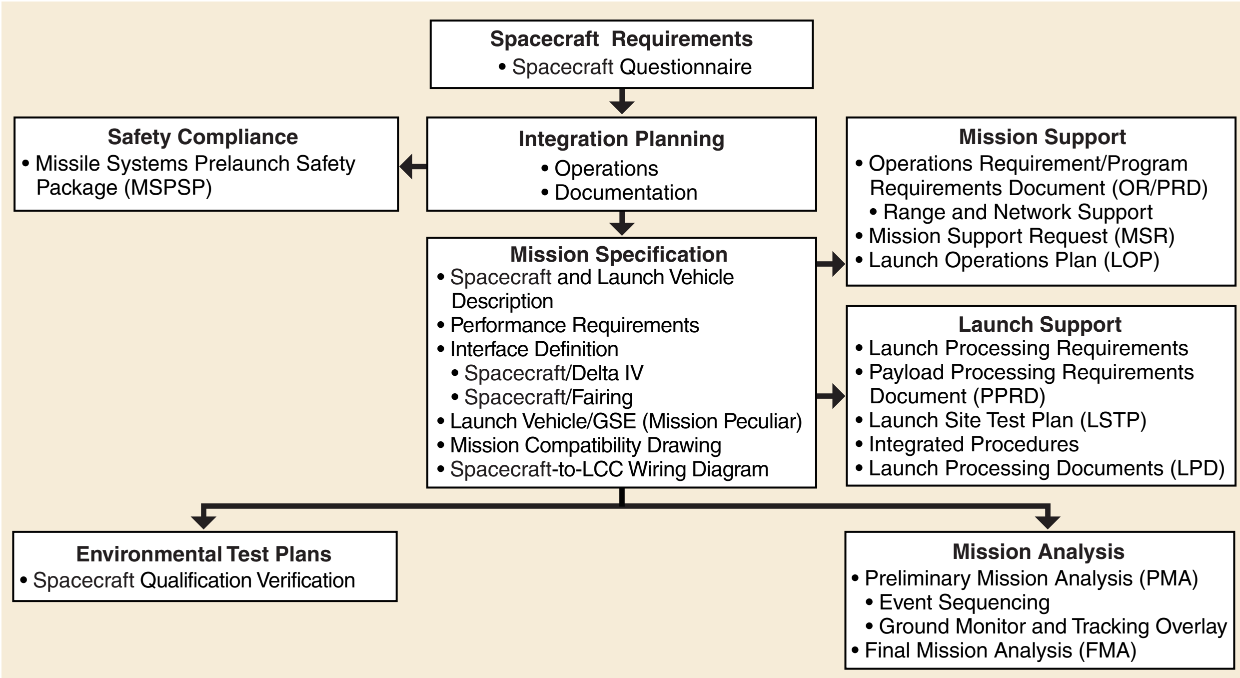


**Figure 8-3. Typical Document Interfaces**

The required documents for a typical mission are listed in Tables 8-1 and 8-2. Table 8-3 describes the contents of the program documents identified. Mission-specific schedules are established by agreement with each customer. The Spacecraft Questionnaire shown in Table 8-4 is normally completed by the payload agency 91 weeks prior to launch to provide an initial definition of payload characteristics and requirements. Table 8-5 is an outline of a typical payload launch-site test plan describing the launch site activities and operations expected in support of the mission. Orbit data at burnout of the final stage are needed to reconstruct the performance of the launch vehicle following the mission. A complete set of orbital elements and associated estimates of 3-$\sigma$ accuracy, presented in Table 8-6 and provided by the customer, is required to reconstruct this performance.

## 8.3 LAUNCH OPERATIONS PLANNING

Development of launch operations, range support, and other support requirements is an evolutionary process that requires timely inputs and continued support from the customer.

## 8.4 PAYLOAD PROCESSING REQUIREMENTS

The checklist shown in Table 8-7 is provided to assist the customer in identifying the requirements at each processing facility. The requirements identified are submitted to Boeing for the program requirements document (PRD). Boeing coordinates with the payload processing facility, and implements the requirements through the PRD/payload processing requirements document (PPRD). The customer may add items to the list.

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| Task Name | OPR | Due Date (Wks) |
|---|---|---|
| 1. Spacecraft Questionnaire | C | L-91 |
| 2. Fairing Requirements | C | L-91 |
| 3. SC Drawings (Initial) | C | L-91 |
| 4. MSPSP Inputs (Initial) | C | L-91 |
| 5. SC Mathematical Model (Initial) | C | L-91 |
| 6. DOT License Information | C | L-91 |
| 7. SC Environmental Test Document (Test Plan) | C | L-85 |
| 8. Separation Analysis (Initial) | B | L-81 |
| 9. Mission Specification (Initial) | B | L-78 |
| 10. SC-to-Control Ctr Wiring Requirements | C | L-78 |
| 11. Mission Specification Comments | C | L-74 |
| 12. Preliminary Mission Analysis (PMA) Rqmts | C | L-73 |
| 13. SC Mass Properties Statement (Initial) | C | L-73 |
| 14. SC Compatibility Drawing (Draft) | B | L-68 |
| 15. Coupled Dynamic Loads Analysis (FDLC) | B | L-66 |
| 16. Radio Frequency Applications Inputs | C | L-65 |
| 17. Preliminary Mission Analysis | B | L-63 |
| 18. SC Compatibility Drawing Comments | B | L-62 |
| 19. SC Compatibility Drawing (Initial) | C | L-56 |
| 20. Final Mission Analysis (FMA) Requirements | B | L-54 |
| 21. Launch Window (Initial) | C | L-54 |
| 22. SC Mass Properties Statement (Update) | C | L-54 |
| 23. Program Requirements Document - SC Inputs | C | L-52 |
| 24. Spacecraft Thermal Model | C | L-52 |
| 25. Mission Operations and Support Requirements | C | L-52 |
| 26. P/L Processing Requirements Document Inputs | C | L-52 |
| 27. SC-to-Control Center Wiring Diagram (Initial) | C | L-52 |
| 28. Radio Frequency Applications (RFA) | B | L-52 |
| 29. DOT License Application | B | L-45 |
| 30. SC Drawings (Final) | C | L-44 |
| 31. SC Ctrl Ctr Wiring Diagram Comments | C | L-44 |
| 32. Final Mission Analysis (FMA) | C | L-44 |
| 33. SC Mathematical Model (Final) | B | L-43 |
| 34. Launch Vehicle Insignia | C | L-40 |
| 35. Payload Processing Requirements Document | B | L-39 |
| 36. SC-to-Control Center Wiring Diagram (Final) | B | L-35 |
| 37. SC Launch Site Test Plan | C | L-34 |
| 38. SC Compatibility Drawing (Final) | B | L-30 |
| 39. SC Launch Site Procedures | C | L-26 |
| 40. Program Requirements Document (PRD) | B | L-26 |
| 41. Coupled Dynamic Loads Analysis (VLC) | B | L-26 |
| 42. SC Integrated Test Procedure Inputs | C | L-26 |
| 43. SC Clearance Drawing | B | L-24 |
| 44. SC Mass Properties Statement (Final, Predicted) | C | L-20 |
| 45. SC Environmental Test Report | C | L-20 |
| 46. Thermal Analysis Report | B | L-20 |
| 47. MSPSP (Final) | B | L-17 |
| 48. Integrated Countdown Schedule | B | L-15 |
| 49. SC Separation Analysis (Final) | B | L-13 |
| 50. RF Compatibility Analysis Report | B | L-12 |
| 51. Launch Window (Final) | C | L-08 |
| 52. Launch Site Procedures | B | L-06 |
| 53. Launch Operations Plan (LOP) | B | L-05 |
| 54. Vehicle Information Memorandum (VIM) | B | L-04 |
| 55. Best-Estimate Trajectory | B | L-02 |
| 56. Launch Readiness Review Data Package | B | L-1d |
| 57. Launch | B | L-0 |
| 58. Post-Launch Report Orbit Confirmation Data | C | L+2hr |
| 59. Post-Launch Report (Final) | B | L+8 |

Months From Launch: -21 -20 -19 -18 -17 -16 -15 -14 -13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1

B = Boeing
C = Customer
d = Days

**Figure 8-4. Typical Integration Planning Schedule**

**Table 8-1. Customer Data Requirements**

| Description | Table 8-3 reference | Nominal due weeks - or + launch |
|---|---|---|
| Spacecraft Questionnaire | 2 | L-91 |
| Fairing Requirements | 8 | L-91 |
| Missile System Prelaunch Safety Package SC Inputs (Initial/Update/Final) | 9 | L-91/L-52/L-26 |
| FAA License Information | 2 | L-91 |
| SC Drawings (Initial/Final) | 18 | L-91/L-44 |
| SC Mathematical Model (Initial/Final) | 3 | L-91/L-43 |
| SC Environmental Test Documents | 5 | L-85 |
| Electrical Wiring Requirements | 7 | L-78 |
| Preliminary Mission Analysis (PMA) Inputs | 11 | L-73 |
| SC Mass Properties Statement (Initial/Update/Final) | 22 | L-73/L-54/L-20 |
| Radio Frequency Applications Inputs | 10 | L-65 |
| SC Compatibility Drawing Comments | 18 | L-62 |
| Final Mission Analysis (FMA) Inputs | 17 | L-54 |
| Launch Window (Initial/Final) | 16 | L-54/L-08 |
| Mission Operational and Support Requirements | 12 | L-52 |
| Payload Processing Requirements Document Inputs | 14 | L-52 |
| Program Requirements Document Inputs | 13 | L-52 |
| SC-to-LCC Wiring Diagram Review | 28 | L-44 |
| Launch Vehicle Insignia | 15 | L-40 |
| Spacecraft Launch Site Test Plan | 19 | L-34 |
| Mission Specification Comments | 4 | 30 days after receipt |
| SC Integrated Test Procedure Inputs | 21 | L-26 |
| SC Launch-Site Procedures | 20 | L-26 |
| Spacecraft Environments and Loads Test Report | 5 | L-20 |
| Postlaunch Orbit Confirmation Data | 27 | L+2 hr |

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**Table 8-2. Boeing Program Documents**

| Description | Table 8-3 reference | Nominal due weeks - or + launch |
|---|---|---|
| SC Separation Analysis (Initial/Final) | 24 | L-81/L-13 |
| Mission Specification (Initial) | 4 | L-78 |
| Coupled Dynamic Loads Analysis (FDLC/VLC) | 6 | L-66/L-26 |
| Preliminary Mission Analysis (PMA) | 11 | L-63 |
| Final Mission Analysis (FMA) | 17 | L-44 |
| Payload Processing Requirements Document (PPRD) | 14 | L-39 |
| SC-to-LCC Wiring Diagram (Final) | 28 | L-35 |
| SC Compatibility Drawing (Final) | 18 | L-30 |
| Program Requirements Document | 14 | L-26 |
| SC-Fairing Clearance Drawing | 18 | L-24 |
| Integrated Countdown Schedule | 30 | L-15 |
| Launch Site Procedures | 29 | L-6 |
| Launch Operations Plan | 25 | L-5 |
| VIM | 26 | L-4 |

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**Table 8-3. Required Documents**

| | Item | Responsibility |
|---|---|---|
| **1.** | **Feasibility Study (Optional)**<br>A feasibility study may be necessary to define the launch vehicle's capabilities for a specific mission or to establish the overall feasibility of using the launch vehicle for performing the required mission. Typical items that may necessitate a feasibility study are (1) a new flight plan with unusual launch azimuth or orbital requirements, (2) a precise accuracy requirement or a performance requirement greater than that available with the standard launch vehicle, and (3) a payload that imposes uncertainties with respect to launch vehicle stability.<br>Specific tasks, schedules, and responsibilities are defined before study initiation, and a final report is prepared at the conclusion of the study. | Boeing |
| **2.** | **Spacecraft Questionnaire**<br>The Spacecraft Questionnaire (Table 8-4) is the first step in the process. It is designed to provide the initial definition of spacecraft requirements, interface details, launch site facilities, and preliminary safety data for Delta's various agencies. It contains a set of questions whose answers define the requirements and interfaces as they are known at the time of preparation. The completed questionnaire is required not later than 2 years prior to launch.<br>A specific response to some questions may not be possible because many items are defined at a later date. Of particular interest are answers that specify requirements in conflict with constraints specified herein. Normally, this document is not kept current; it will be used to create the initial issue of the mission specification (Item 4) and in support of our Federal Aviation Administration (FAA)/Department of Transportation (DOT) launch permit.<br>The specified items are typical of the data required for Delta IV missions. The spacecraft contractor is encouraged to include other pertinent information regarding mission requirements or constraints. | Customer |
| **3.** | **Spacecraft Mathematical Model for Dynamic Analysis**<br>A spacecraft mathematical model is required for use in a coupled loads analysis. Acceptable forms include (1) a discrete math model with associated mass and stiffness matrices or (2) a constrained normal mode model with modal mass and stiffness and the appropriate transformation matrices to recover internal responses. Required model information such as specific format, degrees-of-freedom requirements, and other necessary information will be supplied. | Customer |
| **4.** | **Mission Specification**<br>The Boeing Mission Specification functions as the Delta launch vehicle interface control document and describes all mission-specific requirements. It contains the spacecraft description, spacecraft-to-operations-building wiring diagram, compatibility drawing, targeting criteria, special spacecraft requirements affecting the standard launch vehicle, description of the mission-specific launch vehicle, a description of special aerospace ground equipment (AGE) and facilities Boeing is required to furnish. The document is provided to spacecraft agencies for review and concurrence and is revised as required. The initial issue is based on data provided in the Spacecraft Questionnaire and is provided approximately 68 weeks before launch. Subsequent issues are published as requirements and data become available. The mission-specific requirements documented in the mission specification, along with the standard interfaces presented in this manual, define the spacecraft-to-launch vehicle interface. | Boeing (input required from Customer) |
| **5.** | **Spacecraft Environmental Test Documents**<br>The environmental test plan documents the spacecraft contractor's approach for qualification and acceptance (preflight screening) tests. It is intended to provide a general test philosophy and an overview of the system-level environmental testing to be performed to demonstrate adequacy of the spacecraft for flight (e.g., static loads, vibration, acoustics, shock). The test plan should include test objectives, test specimen configuration, general test methods, and a schedule. It should not include detailed test procedures.<br>Following the system-level structural loads and dynamic environment testing, test reports documenting the results shall be provided to Boeing. These reports should summarize the testing performed to verify the adequacy of the spacecraft structure for the flight loads. For structural systems not verified by test, a structural loads analysis report documenting the analyses performed and resulting margins of safety should be provided to Boeing. | Customer |
| **6.** | **Coupled Dynamic Loads Analysis**<br>A coupled dynamic loads analysis is performed to define flight loads to major launch vehicle and spacecraft structures. The liftoff event, which generally causes the most severe lateral loads in the spacecraft, and the period of transonic flight and maximum dynamic pressure, causing the greatest relative deflections between the spacecraft and fairing, are generally included in this analysis. Output for each flight event includes tables of maximum acceleration at selected nodes of the spacecraft model as well as a summary of maximum interface loads. Worst-case spacecraft-fairing dynamic relative deflections are included. Close coordination between the user and the Delta IV mission integration is essential so that the output format and the actual work schedule for the analysis can be defined. | Boeing (input required from Customer, item 3) |

**Table 8-3. Required Documents (Continued)**

| | Item | Responsibility |
|---|---|---|
| 7. | **Electrical Wiring Requirements**<br>The wiring requirements for the spacecraft to the launch control center (LCC) and the payload processing facilities are needed as early as possible. Section 5 lists the Delta capabilities and outlines details that must be supplied. Boeing will provide a spacecraft-to-operations-building wiring diagram based on the spacecraft requirements. It will define the hardware interface from the spacecraft to the LCC for control and monitoring of spacecraft functions after spacecraft installation in the launch vehicle. Close attention to the documentation schedule is required so that production checkout of the launch vehicle includes all of the mission-specific wiring. Any requirements for the payload processing facilities are to be furnished with the LCC information. | Customer |
| 8. | **Fairing Requirements**<br>Early spacecraft fairing requirements should be addressed in the questionnaire and updated in the mission specification. Final spacecraft requirements are needed to support the mission-specific fairing modifications during production. Any in-flight requirements, ground requirements, critical spacecraft surfaces, surface sensitivities, mechanical attachments, RF transparent windows, and internal temperatures on the ground and in flight must be provided. | Customer |
| 9. | **Missile System Prelaunch Safety Package (MSPSP) (Refer to EWR 127-1 for specific spacecraft safety regulations)**<br>To obtain approval to use the launch site facilities and resources for launch, an MSPSP must be prepared and submitted to Delta IV mission integration. The MSPSP includes a description of each hazardous system (with drawings, schematics, and assembly and handling procedures, as well as any other information that will aid in appraising the respective systems) and evidence of compliance with the safety requirements of each hazardous system. The major categories of hazardous systems are ordnance devices, radioactive material, propellants, pressurized systems, toxic materials and cryogenics, and RF radiation. The specific data required and suggested formats are discussed in Section 2 of EWR 127-1. Boeing will provide this information to the appropriate government safety offices for their approval. | Customer and Boeing |
| 10. | **Radio Frequency (RF) Applications**<br>The spacecraft contractor is required to specify the RF transmitted by the spacecraft during ground processing and launch intervals. An RF data sheet specifying individual frequencies will be provided. Names and qualifications are required covering spacecraft contractor personnel who will operate spacecraft RF systems. Data such as transmission frequency bandwidths, frequencies, radiated durations, and wattage will be provided. Boeing will provide these data to the appropriate range/government agencies for approval. | Customer and Boeing |
| 11. | **Preliminary Mission Analysis (PMA)**<br>This analysis is normally the first step in the mission-planning process. It uses the best-available mission requirements (spacecraft weight, orbit requirements, tracking requirements, etc.) and is primarily intended to uncover and resolve any unusual problems inherent in accomplishing the mission objectives. Specifically, information pertaining to launch vehicle environment, performance capability, sequencing, and orbit dispersion is presented. Parametric performance and accuracy data are usually provided to assist the user in selection of final mission orbit requirements. The orbit dispersion data are presented in the form of variations of the critical orbit parameters as functions of probability level. A covariance matrix and a trajectory printout are also included.<br><br>The mission requirements and parameter ranges of interest for parametric studies are due as early as possible but in no case later than L-64 weeks. Comments to the PMA are needed no later than L-40 weeks for start of the FMA (Item 17). | Boeing (input required from Customer) |
| 12. | **Mission Operational and Support Requirements**<br>To obtain unique range and network support, the spacecraft contractor must define any range or network requirements appropriate to the mission and submit them to Boeing. Spacecraft contractor operational configuration, communication, tracking, and data flow are required to support document preparation and to arrange for required range support. | Customer |
| 13. | **Program Requirements Document (PRD)**<br>To obtain range and network support, a spacecraft PRD must be prepared. This document consists of a set of preprinted standard forms (with associated instructions) that must be completed. The spacecraft contractor will complete all forms appropriate to the mission and submit them to Boeing. Boeing will compile, review, provide comments, and, upon comment resolution, forward the spacecraft PRD to the appropriate support agency for formal acceptance. | Boeing (input required from Customer) |
| 14. | **Payload Processing Requirements Document (PPRD)**<br>The PPRD is prepared if commercial facilities are to be used for spacecraft processing. The spacecraft contractor is required to provide data on all spacecraft activities to be performed at the commercial facility. This includes detailed information on all facilities, services, and support requested by Boeing to be provided by the commercial facility. Spacecraft hazardous systems descriptions shall include drawings, schematics, summary test data, and any other available data that will aid in appraising the respective hazardous system. The commercial facility will accept spacecraft ground operations plans and/or MSPSP data for the PPRD. | Boeing (input required from Customer) |

**Table 8-3. Required Documents (Continued)**

| | Item | Responsibility |
|---|---|---|
| 15. | **Launch Vehicle Insignia**<br>The customer is entitled to have a mission-specific insignia placed on the launch vehicle. The customer will submit the proposed design to Boeing not later than 9 months before launch for review and approval. Following approval, Boeing will have the flight insignia prepared and placed on the launch vehicle. The maximum size of the insignia is 4.7 m by 4.7 m (15 ft by 15 ft). The insignia is placed on the uprange side of the launch vehicle. | Customer |
| 16. | **Launch Window**<br>The spacecraft contractor is required to specify the maximum launch window for any given day. Specifically, the window opening time (to the nearest minute) and the window closing time (to the nearest minute) are to be specified. This final window data should extend for at least 2 weeks beyond the scheduled launch date. Liftoff is targeted to the specified window opening. | Customer |
| 17. | **Final Mission Analysis (FMA) Report**<br>Boeing will issue an FMA trajectory report that provides the mission reference trajectory. The FMA contains a description of the flight objectives, the nominal trajectory printout, a sequence of events, vehicle attitude rates, spacecraft and launch vehicle tracking data, and other pertinent information. The trajectory is used to develop mission targeting constants and represents the flight trajectory. The FMA will be available at L-26 weeks. | Boeing (input required from Customer) |
| 18. | **Spacecraft Drawings**<br>Spacecraft configuration drawings are required as early as possible. The drawings should show nominal and worst-case (maximum tolerance) dimensions and a tabulated definition of the physical location of all points on the spacecraft that are within 51 mm (2 in.) of the allowable spacecraft envelope for the compatibility drawing prepared by Boeing, clearance analysis, fairing compatibility, and other interface details. Spacecraft drawings are desired with the Spacecraft Questionnaire. The drawings should be 0.20 scale and transmitted via CAD media. Details should be worked out through Delta IV mission integration. | Customer |
| | Boeing will prepare and release the spacecraft compatibility drawing that will become part of the mission specification. This is a working drawing that identifies spacecraft-to-launch-vehicle interfaces. It defines electrical interfaces; mechanical interfaces, including spacecraft-to-PAF separation plane, separation springs and spring seats, and separation switch pads; definition of stay-out envelopes, both internal and external to the PAF; definition of stay-out envelopes within the fairing; and location and mechanical activation of spring seats. The spacecraft contractor reviews the drawing and provides comments, and upon comment resolution and incorporation of the final spacecraft drawings, the compatibility drawing is formally accepted as a controlled interface between Boeing and the spacecraft agency. In addition, Boeing will provide a worst-case spacecraft-fairing clearance drawing. | Boeing |
| 19. | **Spacecraft Launch Site Test Plan**<br>To provide all agencies with a detailed understanding of the launch site activities and operations planned for a particular mission, the spacecraft contractor is required to prepare a launch site test plan. The plan is intended to describe all aspects of the program while at the launch site. A suggested format is shown in Table 8-5. | Customer |
| 20. | **Spacecraft Launch Site Procedures**<br>Operating procedures must be prepared for all operations that are accomplished at the launch site. For operations that are hazardous (either to equipment or to personnel), special instructions must be followed in preparing the procedures. Refer to Section 9. | Customer |
| 21. | **Spacecraft Integrated Test Procedure Inputs**<br>On each mission, Boeing prepares launch site procedures for various operations that involve the spacecraft after it is mated with the Delta second stage. Included are requirements for operations such as spacecraft weighing, spacecraft installation to the third stage and encapsulation into the fairing, transportation to the launch complex, hoisting into the mobile service tower (MST) enclosure, spacecraft/third stage mating to the launch vehicle, flight program verification test, and launch countdown. Boeing requires inputs to these operations in the form of handling constraints, environmental constraints, personnel requirements, and equipment requirements. Of particular interest are spacecraft tasks/requirements during the final week before launch. (Refer to Section 6 or Section 7 for schedule constraints.) | Customer |
| 22. | **Spacecraft Mass Properties Statement**<br>The data from the spacecraft mass properties report represent the best current estimate of final spacecraft mass properties. The data should include any changes in mass properties while the spacecraft is attached to the Delta launch vehicle. Values quoted should include nominal and 3-$\sigma$ uncertainties for mass, centers of gravity, moments of inertia, products of inertia, and principal axis misalignment. | Customer |
| 23. | **RF Compatibility Analysis**<br>A radio frequency interference (RFI) analysis is performed to verify that spacecraft RF sources are compatible with the launch vehicle telemetry and tracking beacon frequencies. Spacecraft frequencies defined in the mission specification are analyzed using a frequency-compatibility software program. The program provides a list of all intermodulation products that are then checked for image frequencies and intermodulation product interference. | Boeing |

**Table 8-3. Required Documents (Continued)**

| | Item | Responsibility |
|---|---|---|
| **24.** | **Spacecraft/Launch Vehicle Separation Memorandum**<br>An analysis is performed to verify that there is adequate clearance and separation distance between the spacecraft and expended PAF/second stage. This analysis verifies adequate clearance between the spacecraft and second stage during separation and second-stage post-separation maneuvers. | Boeing (input required from Customer) |
| **25.** | **Launch Operations Plan (LOP)**<br>This plan is developed to define top-level requirements that flow down into detailed range requirements. The plan contains the launch operations configuration that identifies data and communication connectivity with all required support facilities. The plan also identifies organizational roles and responsibilities, the mission control team and its roles and responsibilities, mission rules supporting conduct of the launch operation, and go/no-go criteria. | Boeing |
| **26.** | **Vehicle Information Memorandum (VIM)**<br>Boeing is required to provide a vehicle information memorandum to the U.S. Space Command 15 calendar days prior to launch. The spacecraft agency will provide to Boeing the appropriate spacecraft on-orbit data required for this VIM. Data required are spacecraft on-orbit descriptions, descriptions of pieces and debris separated from the spacecraft, the orbital parameters for each piece of debris, payload spin rates, and orbital parameter information for each different orbit through final orbit. Boeing will incorporate these data into the overall VIM and transmit it to the appropriate U.S. government agency. | Boeing |
| **27.** | **Postlaunch Orbit Confirmation Data**<br>To reconstruct Delta performance, orbit data at burnout (stage II or III) are required from the spacecraft contractor. The spacecraft contractor should provide orbit conditions at the burnout epoch based on spacecraft tracking prior to any orbit-correction maneuvers. A complete set of orbital elements and associated estimates of 3-$\sigma$ accuracy is required (see Table 8-6). | Customer |
| **28.** | **Spacecraft-to-Launch Control Center (LCC) Wiring Diagram**<br>For inclusion in the Mission Specification, Boeing will provide a spacecraft-to-LCC wiring diagram based on the spacecraft requirements. It will define the hardware interface from the spacecraft to the LCC for control and monitoring of spacecraft functions after spacecraft installation in the launch vehicle. | Boeing |
| **29.** | **Launch Site Procedures**<br>Boeing prepares procedures, called launch preparation documents (LPDs), that are used to authorize work on the flight hardware and related ground equipment. Most are applicable to the booster and second-stage operations, but a few are used to control and support stand-alone spacecraft and integrated activities at the payload processing facility and on the launch pad after encapsulated payload mate. These documents are prepared by Boeing based on Boeing requirements; the inputs provided by the spacecraft contractor are listed in Item 21 and are available for review by the customer. LPDs are usually released a few weeks prior to use. | Boeing |
| **30.** | **Countdown Bar Charts**<br>Daily schedules are prepared on hourly timelines for integrated activities at the launch pad following encapsulated spacecraft mate to the second stage. These schedules are prepared by the Boeing chief test conductor based on standard Boeing launch operations, mission-specified requirements, and inputs provided by the spacecraft contractor as described in the mission specification. (Typical schedules are shown in Sections 6 and 7) A draft is prepared several months prior to launch and released to the customer for review. The final is normally released several weeks prior to encapsulated spacecraft mate at the pad. | Boeing |

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**Table 8-4. Delta IV Spacecraft Questionnaire**

Note: When providing numerical parameters, please specify either English or metric units.

**1 Spacecraft/Constellation Characteristics**

1.1 Spacecraft Description

1.2 Size and Space Envelope

1.2.1 Dimensioned Drawings/CAD Model of the Spacecraft in the Launch Configuration

1.2.2 Protuberances Within 76 mm/3.0 in. of Allowable Fairing Envelope Below Separation Plane (Identify Component and Location)

1.2.3 Appendages Below Separation Plane (Identify Component and Location)

1.2.4 On-Pad Configuration (Description and Drawing)

Figure 1.2.4-1. SC On-Pad Configuration

1.2.5 Orbit Configuration (Description and Drawing)

Figure 1.2.5-2. SC On-Orbit Configuration

Figure 1.2.5-3. Constellation On-Orbit Configuration (if applicable)

1.3 Spacecraft Mass Properties

1.3.1 Weight, Moments and Products of Inertia, and CG Location

1.3.2 Principal Axis Misalignment

1.3.3 Fundamental Frequencies (Thrust Axis/Lateral Axis)

1.3.4 Are All Significant Vibration Modes Above Levels Specified in Section 4 of the Payload Planners Guide?

**Table 1.3.4-1. SC Stiffness Requirements**

| Spacecraft | Fundamental frequency (Hz) | Axis |
|---|---|---|
| | | Lateral<br>Axial |

1.3.5 Description of Spacecraft Dynamic Model

Mass Matrix

Stiffness Matrix

Response-Recovery Matrix

1.3.6 Time Constant and Description of Spacecraft Energy Dissipation Sources and Locations (e.g., Hydrazine Fill Factor, Passive Nutation Dampers, Flexible Antennae)

1.3.7 Spacecraft Coordinate System

**Table 1.3.7-1. Individual SC Mass Properties**

| Description | Axis | Value | ±3-$\sigma$ uncertainty |
|---|---|---|---|
| Weight (unit) | N/A | | |
| Center of Gravity (unit) | X<br>Y<br>Z | | |
| Moments of Inertia (unit) | $I_{XX}$<br>$I_{YY}$<br>$I_{ZZ}$ | | |
| Products of Inertia (unit) | $I_{XY}$<br>$I_{YZ}$<br>$I_{ZX}$ | | |

**Table 1.3.7-2. Entire Payload Mass Properties (All SCs and Dispenser Combined)**

| Description | Axis | Value | ±3-$\sigma$ uncertainty |
|---|---|---|---|
| Weight (unit) | N/A | | |
| Center of Gravity (unit) | X<br>Y<br>Z | | |
| Moments of Inertia (unit) | $I_{XX}$<br>$I_{YY}$<br>$I_{ZZ}$ | | |
| Products of Inertia (unit) | $I_{XY}$<br>$I_{YZ}$<br>$I_{ZX}$ | | |

**Table 8-4. Delta IV Spacecraft Questionnaire (Continued)**

1.4 Spacecraft Hazardous Systems
- 1.4.1 Propulsion System
  - 1.4.1.1 Apogee Motor (Solid or Liquid)
  - 1.4.1.2 Hydrazine (Quantity, Spec, etc.)
  - 1.4.1.3 Do Pressure Vessels Conform to Safety Requirements of Delta Payload Planners Guide Section 9?
  - 1.4.1.4 Location Where Pressure Vessels Are Loaded and Pressurized

**Table 1.4.1-1. Propulsion System Characteristics**

| Parameter | Value |
|---|---|
| Propellant Type | |
| Propellant Weight, Nominal (unit) | |
| Propellant Fill Fraction | |
| Propellant Density (unit) | |
| Propellant Tanks | |
| Propellant Tank Location (SC coordinates)<br>Station (unit)<br>Azimuth (unit)<br>Radius (unit) | |
| Internal Volume (unit) | |
| Capacity (unit) | |
| Diameter (unit) | |
| Shape | |
| Internal Description | |
| Operating Pressure—Flight (unit) | |
| Operating Pressure—(MEOP) Ground (unit) | |
| Design Burst Pressure—Calculated (unit) | |
| Factor of Safety (Design Burst/Ground MEOP) | |
| Actual Burst Pressure—Test (unit) | |
| Proof Pressure—Test (unit) | |
| Pressurized at (location) | |
| Tank Material | |

**Table 1.4.1-2. Pressurized Tank Characteristics**

| Parameter | Value |
|---|---|
| Operating Pressure—Flight (unit) | |
| Operating Pressure—MEOP Ground (unit) | |
| Design Burst Pressure—Calculated (unit) | |
| Factor of Safety (Design Burst/Ground MEOP) (unit) | |
| Actual Burst Pressure—Test (unit) | |
| Proof Pressure—Test (unit) | |
| Vessel Contents | |
| Capacity—Launch (unit) | |
| Quantity—Launch (unit) | |
| Purpose | |
| Pressurized at (location) | |
| Pressure When Boeing Personnel Are Exposed (unit) | |
| Tank Material | |
| Number of Vessels Used | |

**Table 8-4. Delta IV Spacecraft Questionnaire (Continued)**

1.4.2 Nonpropulsion Pressurized Systems
1.4.2.1 High-Pressure Gas (Quantity, Spec, etc.)
1.4.2.2 Other
1.4.3 Spacecraft Batteries (Quantity, Voltage, Environmental/Handling Constraints, etc.)

**Table 1.4.3-1. Spacecraft Battery**

| Parameter | Value |
|---|---|
| Electrochemistry | |
| Battery Type | |
| Electrolyte | |
| Battery Capacity (unit) | |
| Number of Cells | |
| Average Voltage/Cell (unit) | |
| Cell Pressure (Ground MEOP) (unit) | |
| Specification Burst Pressure (unit) | |
| Actual Burst (unit) | |
| Proof Tested (unit) | |

1.4.4 RF Systems
1.4.4.1 Distance at Which RF Radiation Flux Density Equals 1 mW/cm$^2$
1.4.4.2 RF Radiation Levels (Personnel Safety)

**Table 1.4.4-1. Transmitters and Receivers**

| | Antennas | | | |
|---|---|---|---|---|
| Parameter | Receiver 1 | Transmitter 2 | 3 | 4 |
| Nominal Frequency (MHz) | | | | |
| Transmitter Tuned Frequency (MHz) | | | | |
| Receiver Frequency (MHz) | | | | |
| Data Rates, Downlink (kbps) | | | | |
| Symbol Rates, Downlink (kbps) | | | | |
| Type of Transmitter | | | | |
| Transmitter Power, Maximum (dBm) | | | | |
| Losses, Minimum (dB) | | | | |
| Peak Antenna Gain (dB) | | | | |
| EIRP, Maximum (dBm) | | | | |
| Antenna Location (base) | | | | |
| Station (unit) | | | | |
| Angular Location | | | | |
| Planned Operation:<br>Prelaunch: In PPF<br>Prelaunch: Pre-Fairing Inspection, On Pad<br>Postlaunch: Before SC Separation, During Ascent | | | | |

**Table 1.4.4-2. Radio Frequency Environment**

| Frequency | E-field |
|---|---|
| | |
| | |
| | |

**Table 8-4. Delta IV Spacecraft Questionnaire (Continued)**

1.4.5 Deployable Systems
1.4.5.1 Antennas
1.4.5.2 Solar Panels
1.4.5.3 Any Deployment Prior to Separation?
1.4.6 Radioactive Devices
1.4.6.1 Can Spacecraft Produce Nonionizing Radiation at Hazardous Levels?
1.4.6.2 Other
1.4.7 Electro-Explosive Devices (EED)
1.4.7.1 Category A EEDs (Function, Type, Part Number, When Installed, When Connected)
1.4.7.2 Are Electrostatic Sensitivity Data Available on Category A EEDs? List References
1.4.7.3 Category B EEDs (Function, Type, Part Number, When Installed, When Connected)
1.4.7.4 Do Shielding Caps Comply With Safety Requirements?
1.4.7.5 Are RF Susceptibility Data Available? List References

**Table 1.4.7-1. Electro-Explosive Devices**

| Quantity | Type | Use | Firing current (amps) | | Bridgewire (ohms) | Where installed | Where connected | Where armed |
|---|---|---|---|---|---|---|---|---|
| | | | No fire | All fire | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

1.4.8 Non-EED Release Devices

**Table 1.4.8-1. Non-Electric Ordnance and Release Devices**

| Quantity | Type | Use | Quantity explosives | Type | Explosives | Where installed | Where connected | Where armed |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

1.4.9 Other Hazardous Systems
1.4.9.1 Other Hazardous Fluids (Quantity, Spec, etc.)
1.4.9.2 Other
1.5 Contamination-Sensitive Surfaces
1.5.1 Surface Sensitivity (e.g., Susceptibility to Propellants, Gases and Exhaust Products, and Other Contaminants)

**Table 1.5-1. Contamination-Sensitive Surfaces**

| Component | Sensitive to | NVR | Particulate | Level |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

1.6 Spacecraft Systems Activated Prior to Spacecraft Separation
1.7 Spacecraft Volume (Ventable and Nonventable)
1.7.1 Spacecraft Venting (Volume, Rate, etc.)
1.7.2 Nonventable Volume
**2 Mission Parameters**
2.1 Mission Description
2.1.1 Summary of Overall Mission Description and Objectives
2.1.2 Number of Launches required
2.1.3 Frequency of Launches required
2.2 Orbit Characteristics

**Table 8-4. Delta IV Spacecraft Questionnaire (Continued)**

**Table 2.2-1. Orbit Characteristics**

| LV and launch site | Mass | Apogee | Perigee | Inclination | Argument of perigee at insertion | RAAN | Eccentricity | Period |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

2.3 Launch Dates and Times
- 2.3.1 Launch Windows (over 1-year span)
- 2.3.2 Launch Exclusion Dates

**Table 2.3.1-1. Launch Windows**

| Launch number | Window open mm/dd/yy hh:mm:ss | Window close mm/dd/yy hh:mm:ss | Window open mm/dd/yy hh:mm:ss | Window close mm/dd/yy hh:mm:ss |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6.... | | | | |

**Table 2.3.2-1. Launch Exclusion Dates**

| Month | Exclusion dates |
|---|---|
| | |
| | |
| | |
| | |
| | |

2.4 Spacecraft Constraints on Mission Parameters
- 2.4.1 Sun-Angle Constraints
- 2.4.2 Eclipse
- 2.4.3 Ascending Node
- 2.4.4 Inclination
- 2.4.5 Telemetry Constraint
- 2.4.6 Thermal Attitude Constraints
- 2.4.7 Other

2.5 Trajectory and Spacecraft Separation Requirement
- 2.5.1 Special Trajectory Requirements
  - 2.5.1.1 Thermal Maneuvers
  - 2.5.1.2 T/M Maneuvers
  - 2.5.1.3 Free Molecular Heating Restraints
- 2.5.2 Spacecraft Separation Requirements
  - 2.5.2.1 Position
  - 2.5.2.2 Attitude
  - 2.5.2.3 Sequence and Timing
  - 2.5.2.4 Tipoff and Coning
  - 2.5.2.5 Spin Rate at Separation
  - 2.5.2.6 Other

**Table 2.5.2-1. Separation Requirements**

| Parameter | Value |
|---|---|
| Angular Momentum Vector (Pointing Error) | |
| Nutation Cone Angle | |
| Relative Separation Velocity (unit) | |
| Tip-Off Angular Rate (unit) | |
| Spin Rate (unit) | |
| Note: The nutation coning angle is a half angle with respect to the angular momentum vector. | |

**Table 8-4. Delta IV Spacecraft Questionnaire (Continued)**

2.6 Launch And Flight Operation Requirements
2.6.1 Operations—Prelaunch
2.6.1.1 Location of Spacecraft Operations Control Center
2.6.1.2 Spacecraft Ground Station Interface Requirements
2.6.1.3 Mission-Critical Interface Requirements
2.6.2 Operations—Launch Through Spacecraft Separation
2.6.2.1 Spacecraft Uplink Requirement
2.6.2.2 Spacecraft Downlink Requirement

**Table 2.6.2-1. Events During Launch Phase**

| Event | Time from liftoff | Constraints/comments |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

2.6.3 Operations—Post-Spacecraft Separation
2.6.3.1 Spacecraft Tracking Station
2.6.3.2 Spacecraft Acquisition Assistance Requirements

**3 Launch Vehicle Configuration**

3.1 Dispenser/Payload Attach Fitting Mission-Specific Configuration
3.1.1 Type of PAF
3.2 Fairing Mission-Specific Configuration
3.2.1 Access Doors and RF Windows in Fairing

**Table 3.2.1-1. Access Doors and RF Windows**

| Size (unit) | LV station (unit)[1] | Clocking (degrees)[2] | Purpose |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| Notes:<br>1. Doors are centered at the locations specified.<br>2. Clocking needs to be measured from Quadrant IV (0/360°) toward Quadrant I (90°). | | | |

3.2.2 Acoustic Blanket Modifications
3.2.3 Air-Conditioning Distribution
3.2.3.1 Spacecraft In-Flight Requirements
3.2.3.2 Spacecraft Ground Requirements (Fairing Installed)
3.2.3.3 Critical Surfaces (i.e., Type, Size, Location)
3.3 Mission-Specific Reliability Requirements
3.4 Mission-Specific Configuration
3.4.1 Extended-Mission Modifications
3.4.2 Retro System

**4 Spacecraft Handling and Processing Requirements**

4.1 Temperature and Humidity

**Table 4.1-1. Ground Handling Environmental Requirements**

| Location | Temperature (unit) | Temperature control | Relative humidity at inlet (unit) | Cleanliness (unit) |
|---|---|---|---|---|
| During Encapsulation | | | | |
| During Transport (Encapsulated) | | | | |
| On-Pad (Encapsulated) | | | | |

**Table 8-4. Delta IV Spacecraft Questionnaire (Continued)**

4.2 Airflow and Purges
- 4.2.1 Airflow and Purges During Transport
- 4.2.2 Airflow and Purges During Hoist Operations
- 4.2.3 Airflow and Purges On-Pad
- 4.2.4 $GN_2$ Instrument Purge
  - Figure 4.2.4-1. $GN_2$ Purge Interface Design

4.3 Contamination/Cleanliness Requirements
- 4.3.1 In PPF
- 4.3.2 During Transport to Pad
- 4.3.3 On Pad
- 4.3.4 Post SC Separation

4.4 Spacecraft Weighing and Balancing
- 4.4.1 Spacecraft Balancing
- 4.4.3 Spacecraft Weighing

4.5 Security
- 4.5.1 PPF Security
- 4.5.2 Transportation Security
- 4.5.3 Pad Security

4.6 Special Handling Requirements
- 4.6.1 Payload Processing Facility Preference and Priority
- 4.6.2 List the Hazardous Processing Facilities the Spacecraft Project Desires to Use
- 4.6.3 What Are the Expected Dwell Times the Spacecraft Project Would Spend in the Payload Processing Facilities?
- 4.6.4 Is a Multishift Operation Planned?
- 4.6.5 Additional Special Boeing Handling Requirements?
- 4.6.6 During Transport
- 4.6.7 On Stand

4.7 Special Equipment and Facilities Supplied by Boeing
- 4.7.1 What Are the Spacecraft and Ground Equipment Space Requirements?
- 4.7.2 What Are the Facility Crane Requirements?
- 4.7.3 What Are the Facility Electrical Requirements?
- 4.7.4 List the Support Items the Spacecraft Project Needs from NASA, USAF, or Commercial Providers to Support the Processing of Spacecraft. Are There Any Unique Support Items?
- 4.7.5 Special AGE or Facilities Supplied by Boeing

4.8 Range Safety
- 4.8.1 Range Safety Console Interface

**5 Spacecraft/Launch Vehicle Interface Requirements**

5.1 Mechanical Interfaces
- 5.1.1 Fairing Envelope
  - 5.1.1.1 Fairing Envelope Violations

**Table 5.1.1.1-1. Violations in the Fairing Envelope**

| Item | LV vertical station (unit) | Radial dimension (unit) | Clocking from SC X-axis | Clocking from LV Quadrant IV axis | Clearance from stay-out zone |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

5.1.1.2 Separation Plane Envelope Violations

**Table 5.1.1.2-1. Violations in the Separation Plane**

| Item | LV vertical station (unit) | Radial dimension (unit) | Clocking from SC X-axis | Clocking from LV Quadrant IV axis | Clearance from stay-out zone |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

- 5.1.2 Separation System
  - 5.1.2.1 Clampband/Attachment System Desired and Interface Diameter

**Table 8-4. Delta IV Spacecraft Questionnaire (Continued)**

**Table 5.1.2.1-1. Spacecraft Mechanical Interface Definition**

| SC bus | Size of S/C interface to LV (unit) | Type of SC interface to LV desired |
|---|---|---|
| | | |
| | | |
| | | |

5.1.2.2 Separation Springs

5.2 Electrical Interfaces

5.2.1 Spacecraft/Payload Attach Fitting Electrical Connectors

5.2.1.1 Connector Types, Location, Orientation, and Part Number

Figure 5.2.1.1-1. Electrical Connector Configuration

5.2.1.2 Connector Pin Assignments in the Spacecraft Umbilical Connector(s)

5.2.1.3 Spacecraft Separation Indication

5.2.1.4 Spacecraft Data Requirements

**Table 5.2.1-1. Interface Connectors**

| Item | P1 | P2 |
|---|---|---|
| Vehicle Connector | | |
| SC Mating Connectors (J1 and J2) | | |
| Distance Forward of SC Mating Plane (unit) | | |
| Launch Vehicle Station | | |
| Clockin* (deg) | | |
| Radial Distance of Connector Centerline from Vehicle Centerline (unit) | | |
| Polarizing Key | | |
| Maximum Connector Force (+Compression, –Tension) (unit) | | |
| *Positional tolerance defined in Payload Planners Guide (reference launch vehicle coordinates). | | |

5.2.2 Separation Switches

5.2.2.1 Separation Switch Pads (Launch Vehicle)

5.2.2.2 Separation Switches (Spacecraft)

5.2.2.3 Spacecraft/Fairing Electrical Connectors

5.2.2.4 Does Spacecraft Require Discrete Signals From Delta?

5.3 Ground Electrical Interfaces

5.3.1 Spacecraft-to-LCC Wiring Requirements

5.3.1.1 Number of Wires Required

5.3.1.2 Pin Assignments in the Spacecraft Umbilical Connector(s)

5.3.1.3 Purpose and Nomenclature of Each Wire Including Voltage, Current, Polarity Requirements, and Maximum Resistance

5.3.1.4 Shielding Requirements

5.3.1.5 Voltage of the Spacecraft Battery and Polarity of the Battery Ground

**Table 5.3.1.5-1. Pin Assignments**

| Pin no. | Designator | Function | Volts | Amps | Max resistance to EED (ohms) | Polarity requirements |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5... | | | | | | |

5.3.2 Spacecraft Ground Support Equipment interface

5.3.2.1 Equipment Consoles (Sizes, Weight, etc.)

5.3.2.2 Interface Ground Cables

5.3.2.3 Auxiliary Boxes (Sizes, Weight, etc.)

5.3.2.4 Other Equipment

**Table 8-4. Delta IV Spacecraft Questionnaire (Continued)**

5.4 Environments Spacecraft is Designed to
5.4.1 Steady-State Acceleration
5.4.2 Quasi-Static Load Factors

**Table 5.4.2-1. Quasi-Static Load Factors**

| | G-Loads (+ is tension, – is compression) | | | | | |
|---|---|---|---|---|---|---|
| | Lateral | | | Axial | | |
| Load event | Static | Dynamic | Total | Static | Dynamic | Total |
| Ground Transport to Pad | | | | | | |
| Liftoff | | | | | | |
| Max. Dynamic Pressure | | | | | | |
| Max. Flight Winds (gust and buffet) | | | | | | |
| Max. Longitudinal Load | | | | | | |
| Max. Axial Load | | | | | | |
| Stage 1 Engine Cutoff | | | | | | |
| Stage 2 Flight | | | | | | |
| Stage 2 Engine Cutoff | | | | | | |
| Pre-Strap-on Nonsymmetric Burnout | | | | | | |

5.4.3 Dynamic Environments
5.4.3.1 Acoustic Environment

**Table 5.4.3.1-1. Spacecraft Acoustic Environment Maximum Flight Levels**

| | | |
|---|---|---|
| Octave Bands (Hz) | | Overall Sound Pressure Level (dB) |
| Level (dB) | | |

5.4.3.2 Vibration

**Table 5.4.3.2-1. Maximum Flight Sinusoidal Vibration Levels**

| | Frequency (Hz) | Level |
|---|---|---|
| Thrust Axis | | |
| Lateral Axes | | |
| Note: Accelerations apply at payload attach fitting base during testing. Responses at fundamental frequencies should be limited based on vehicle coupled loads analysis. | | |

5.4.3.3 Spacecraft Interface Shock Environment

**Table 5.4.3.3-1. Maximum Flight Level Interface Environment**

| Frequency (Hz) | Shock response spectrum level (Q = 10) |
|---|---|
| 100 | |
| 100 to 1500 | |
| 1500 to 10,000 | |

5.4.4 Thermal Environment
5.4.5 RF Environment Susceptibility
5.4.6 Electrical Bonding
5.4.7 Power to the SCs
5.4.8 Fairing Internal Pressure Environment
5.4.9 Humidity Requirements

**Table 8-4. Delta IV Spacecraft Questionnaire (Continued)**

**6 Spacecraft Development and Test Programs**
- 6.1 Test Schedule at Launch Site
  - 6.1.1 Operations Flow Chart (Flow Chart Should Be a Detailed Sequence of Operations Referencing Days and Shifts and Location)
- 6.2 Spacecraft Development and Test Schedules
  - 6.2.1 Flow Chart and Test Schedule
  - 6.2.2 Is a Test PAF Required? When?
  - 6.2.3 Is Clamp Band Ordnance Required? When?
- 6.3 Special Test Requirements
  - 6.3.1 Spacecraft Spin Balancing
  - 6.3.2 Other

**7 Identify Any Additional Spacecraft or Mission Requirements That Are Outside of the Boundary of the Constraints Defined in the Payload Planners Guide**

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**Table 8-5. Typical Spacecraft Launch-Site Test Plan**

**1 General**
- 1.1 Plan Organization
- 1.2 Plan Scope
- 1.3 Applicable Documents
- 1.4 Spacecraft Hazardous Systems Summary

**2 Prelaunch/Launch Test Operations Summary**
- 2.1 Schedule
- 2.2 Layout of Equipment (Each Facility) (Including Test Equipment)
- 2.3 Description of Event at Launch Site
  - 2.3.1 Spacecraft Delivery Operations
    - 2.3.1.1 Spacecraft Removal and Transport to Spacecraft Processing Facility
    - 2.3.1.2 Handling and Transport of Miscellaneous Items (Ordnance, Motors, Batteries, Test Equipment, Handling and Transportation Equipment)
  - 2.3.2 Payload Processing Facility Operations
    - 2.3.2.1 Spacecraft Receiving Inspection
    - 2.3.2.2 Battery Inspection
    - 2.3.2.3 Reaction Control System (RCS) Leak Test
    - 2.3.2.4 Battery Installation
    - 2.3.2.5 Battery Charging
    - 2.3.2.6 Spacecraft Validation
    - 2.3.2.7 Solar Array Validation
    - 2.3.2.8 Spacecraft/Data Network Compatibility Test Operations
    - 2.3.2.9 Spacecraft Readiness Review
    - 2.3.2.10 Preparation for Transport, Spacecraft Encapsulation, and Transport to Hazardous Processing Facility (HPF)
  - 2.3.3 Solid Fuel Storage Area
    - 2.3.3.1 Apogee Kick Motor (AKM) Receiving, Preparation, and X-Ray
    - 2.3.3.2 Safe and Arm (S&A) Device Receiving, Inspection, and Electrical Test
    - 2.3.3.3 Igniter Receiving and Test
    - 2.3.3.4 AKM/S&A Assembly and Leak Test
  - 2.3.4 HPF
    - 2.3.4.1 Spacecraft Receiving Inspection
    - 2.3.4.2 Preparation for AKM Installation
    - 2.3.4.3 Mate AKM to Spacecraft
    - 2.3.4.4 Spacecraft Weighing (Include Configuration Sketch and Approximate Weights of Handling Equipment)
    - 2.3.4.5 Spacecraft/Fairing Mating
    - 2.3.4.6 Preparation for Transport
    - 2.3.4.7 Transport to Launch Complex
  - 2.3.5 Launch Complex Operations
    - 2.3.5.1 Spacecraft/Fairing Hoisting
    - 2.3.5.2 Spacecraft/Fairing Mate to Launch Vehicle
    - 2.3.5.3 Hydrazine Leak Test
    - 2.3.5.4 Telemetry, Tracking, and Command (TT&C) Checkout
    - 2.3.5.5 Preflight Preparations
    - 2.3.5.6 Launch Countdown
- 2.4 Launch/Hold Criteria
- 2.5 Environmental Requirement for Facilities During Transport

**3 Test Facility Activation**
- 3.1 Activation Schedule
- 3.2 Logistics Requirements
- 3.3 Equipment Handling
  - 3.3.1 Receiving
  - 3.3.2 Installation
  - 3.3.3 Validation
  - 3.3.4 Calibration
- 3.4 Maintenance
  - 3.4.1 Spacecraft
  - 3.4.2 Launch-Critical Mechanical Aerospace Ground Equipment (AGE) and Electrical AGE

**4 Administration**
- 4.1 Test Operations—Organizational Relationships and Interfaces (Personnel Accommodations, Communications)

**5 Security Provisions for Hardware**

**6 Special Range-Support Requirements**
- 6.1 Real-Time Tracking Data Relay Requirements
- 6.2 Voice Communications
- 6.3 Mission Control Operations

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**Table 8-6. Data Required for Orbit Parameter Statement**

1. Epoch: Second-stage burnout

2. Position and velocity components $(X, Y, Z, \dot{X}, \dot{Y}, \dot{Z})$ in equatorial inertial Cartesian coordinates.* Specify mean-of-date or true-of-date, etc.

3. Keplerian elements* at the above epoch:
   Semimajor axis, a
   Eccentricity, e
   Inclination, I
   Argument of perigee, $\omega$
   Mean anomaly, M
   Right ascension of ascending node, $\Omega$

4. Polar elements* at the above epoch:
   Inertial velocity, V
   Inertial flight path angle, $\gamma 1$
   Inertial flight path angle, $\gamma 2$
   Radius, R
   Geocentric latitude, $\rho$
   Longitude, $\mu$

5. Estimated accuracies of elements and a discussion of quality of tracking data and difficulties such as reorientation maneuvers within 6 hr of separation, etc.

6. Constants used:
   Gravitational constant, $\mu$
   Equatorial radius, $R_E$
   $J_2$ or Earth model assumed

7. Estimate of spacecraft attitude and coning angle at separation (if available).

*Note: At least one set of orbit elements in Items 2, 3, or 4 is required.

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**Table 8-7. Spacecraft Checklist**

**1. General**
- A. Transportation of spacecraft elements/ground support equipment (GSE) to processing facility
  - (1) Mode of transportation ____________________
  - (2) Arriving at (gate, skid strip)____________________
    (date) ______________________________
- B. Data-handling
  - (1) Send data to (name and address) ______________
  - (2) Time needed (real time versus after the fact)_______
- C. Training and medical examinations for ________________________ crane operators
- D. Radiation data
  - (1) Ionizing radiation materials _________________
  - (2) Nonionizing radiation materials/systems _________ ________________________________

**2. Spacecraft Processing Facility (for nonhazardous work)**
- A. Does payload require a cleanroom? (yes) _____ (no) ____
  - (1) Class of cleanroom required ________________
  - (2) Special sampling techniques ________________
- B. Area required
  - (1) For spacecraft ________________________
  - (2) For ground station ______________________
  - (3) For office space _______________________
  - (4) For other GSE _________________________
  - (5) For storage ___________________________
- C. Largest door size
  - (1) For spacecraft/GSE ____________________
    (high) _________________(wide)__________
  - (2) For ground station ______________________
- D. Material-handling equipment
  - (1) Cranes
    - a. Capacity __________________________
    - b. Minimum hook height __________________
    - c. Travel _____________________________
  - (2) Other ______________________________
- E. Environmental controls for spacecraft/ground station
  - (1) Temperature/humidity and tolerance limits _______ ________________________________
  - (2) Frequency of monitoring___________________
  - (3) Downtime allowable in the event of a system failure ________________________________
  - (4) Is a backup (portable) air-conditioning system required? (yes) _____ (no) ____
  - (5) Other ______________________________
- F. Electrical power for payload and ground station
  - (1) kVA required ___________________________
  - (2) Any special requirements such as clean/quiet power, or special phasing? Explain _________________ ________________________________
  - (3) Backup power (diesel generator) ______________
- G. Communications (list)
  - (1) Administrative telephone ___________________
  - (2) Commercial telephone ____________________
  - (3) Commercial data phones __________________
  - (4) Fax machines__________________________
  - (5) Operational intercom system ________________
  - (6) Closed-circuit television ___________________
  - (7) Countdown clocks _______________________
  - (8) Timing ________________________________
  - (9) Antennas ______________________________
  - (10) Data lines (from/to where) ________________
  - (11) Type (wideband/narrowband)________________
- H. Services general
  - (1) Gases
    - a. Specification__________________________
      Procured by user? _________ KSC?______
    - b. Quantity ___________________________
    - c. Sampling (yes)______ (no)_____
  - (2) Photographs/Video _______ (qty/B&W/color) ____
  - (3) Janitorial (yes) _____________ (no)________
  - (4) Reproduction services (yes) _______ (no) _______
- I. Security (yes) ________________ (no) ____________
  - (1) Safes ________________________ (number/type)
- J. Storage ___________________________ (size area) ______________________________(environment)
- K. Other _________________________________
- L. Spacecraft payload processing facility (PPF) activities calendar
  - (1) Assembly and testing_____________________
  - (2) Hazardous operations
    - a. Initial turn-on of a high-power RF system ______
    - b. Category B ordnance installation ___________
    - c. Initial pressurization ____________________
    - d. Other ______________________________
- M. Transportation of payloads/GSE from PPF to HPF
  - (1) Will spacecraft agency supply transportation canister?_______________________________
    If no, explain ______________________________
  - (2) Equipment support, (e.g., mobile crane, flatbed) _________________________________
  - (3) Weather forecast (yes) __________ (no) ________
  - (4) Security escort (yes) __________ (no) _________
  - (5) Other _________________________________

**3. Hazardous Processing Facility**
- A. Does spacecraft require a cleanroom? (yes)__ (no) __
  - (1) Class of clean room required _______________
  - (2) Special sampling techniques (e.g., hydrocarbon monitoring) ____________________________
- B. Area required
  - (1) For spacecraft ___________________________
  - (2) For GSE ______________________________
    - a. Continuous ___________________________
    - b. During critical tests _____________________
- C. Largest door size
  - (1) For payload ___________high _________wide
  - (2) For GSE ______________high _________wide
- D. Material handling equipment
  - (1) Cranes
    - a. Capacity _____________________________
    - b. Hook height ___________________________
    - c. Travel _______________________________
  - (2) Other _________________________________
- E. Environmental controls spacecraft/GSE
  - (1) Temperature/humidity and tolerance limits _______ _________________________________
  - (2) Frequency of monitoring ___________________
  - (3) Down-time allowable in the event of a system failure _________________________________
  - (4) Is a backup (portable) system required? (yes) _____ (no) ____
  - (5) Other _________________________________
- F. Power for spacecraft and GSE
  - (1) kVA required ____________________________

Note: Please specify units as applicable

**Table 8-7. Spacecraft Checklist (Continued)**

G. Communications (list)
  (1) Administrative telephone ______________________
  (2) Commercial telephone ______________________
  (3) Completed data phones ______________________
  (4) Fax machines ______________________
  (5) Operational intercom system ______________________
  (6) Closed-circuit television ______________________
  (7) Countdown clocks ______________________
  (8) Timing ______________________
  (9) Antennas ______________________
  (10) Data lines (from/to where) ______________________
H. Services general
  (1) Gases
    a. Specification ______________________
       Procured by user ____________ KSC? _______
    b. Quantity ______________________
    c. Sampling (yes) __________ (no) ___________
  (2) Photographs/Video _______ (qty/B&W/color) ____
  (3) Janitorial (yes) _____________ (no) ___________
  (4) Reproduction services (yes) _______ (no) _______
I. Security (yes) ________________ (no) _____________
  (1) Safes ______________________ (number/type)
J. Storage ______________________ (size area)
  ______________________ (environment)
K. Other ______________________
L. Spacecraft PPF activities calendar ______________________
  (1) Assembly and testing ______________________
  (2) Hazardous operations ______________________
    a. Category A ordnance installation ____________
    b. Fuel loading ______________________
    c. Mating operations (hoisting) ______________
M. Transportation of encapsulated payloads to launch pad
  (1) Security escort (yes) ___________ (no) _________
  (2) Other ______________________

**4. Launch Complex Mobile Service Tower (MST) Enclosure**

A. Environmental controls payload/GSE
  (1) Temperature/humidity and tolerance limits
  ______________________
  (2) Any special requirements such as clean/quiet power?
  Please detail requirements ______________________
  (3) Backup power (diesel generator)
    a. Continuous ______________________
    b. During critical tests ______________________
  (4) Hydrocarbon monitoring required ______________________
  (5) Frequency of monitoring ______________________
  (6) Down-time allowable in the event of a system failure ______________________
  ______________________
  (7) Other ______________________
B. Power for payload and GSE
  (1) kVA required ______________________
  (2) Any special requirements such as clean/quiet power/phasing? Explain ______________________
  (3) Backup power (diesel generator)
    a. Continuous ______________________
    b. During critical tests ______________________
C. Communications (list)
  (1) Operational intercom system ______________________
  (2) Closed-circuit television ______________________
  (3) Countdown clocks ______________________
  (4) Timing ______________________
  (5) Antennas ______________________
  (6) Data lines (from/to where) ______________________
D. Services general
  (1) Gases
    a. Specification ______________________
       Procured by user _________ KSC? ________
    b. Quantity ______________________
    c. Sampling (yes) __________ (no) __________
  (2) Photographs/Video ______ (qty/B&W/color) ____
E. Security (yes) _____________(no) ________________
F. Other ______________________
G. Stand-alone testing (does not include tests involving the Delta IV launch vehicle)
  (1) Tests required ______________________
  (e.g., RF system checkout, encrypter checkout)
  (2) Communications required for ______________________
  (e.g., antennas, data lines)
  (3) Spacecraft servicing required ______________________
  (e.g., cryogenics refill)

Note: Please specify units as applicable

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# Section 9
# SAFETY

This section discusses the safety requirements that govern a payload to be launched by a Delta IV launch vehicle from Cape Canaveral Air Force Station (CCAFS), Florida, or Vandenberg Air Force Base (VAFB), California. This section provides safety requirements guidance for payload processing operations conducted at Space Launch Complex 37B (CCAFS) or Space Launch Complex 6 (VAFB).

Payload prelaunch operations may be conducted at Kennedy Space Center (KSC), Florida; Cape Canaveral Air Force Station, Florida; Astrotech in Titusville, Florida; Astrotech in Vandenberg Air Force Base, California; or Spaceport Systems International in Vandenberg Air Force Base, California, by arrangement with the appropriate agencies. Payload operations conducted at Astrotech facilities shall be conducted in accordance with Astrotech ground safety polices. Payload operations conducted at Spaceport Systems International facilities shall be conducted in accordance with Spaceport Systems International ground safety polices. Payload operation conducted at U.S. government facilities shall be conducted in accordance with the government facilities ground safety requirements.

Payload transportation operations conducted on public highways shall be conducted in accordance with Code of Federal Regulations (CFR), Title 49, Department of Transportation, Transportation of Hazardous Materials.

The USAF 45th and 30th Space Wings are responsible for overall range (ground/flight) safety at CCAFS and VAFB, respectively, and are primarily concerned with payload flight and public safety concerns associated with cryogenic, solid fuel, hypergolic fuel, or early flight termination system (FTS) action catastrophic hazards. Payload operations conducted under the jurisdiction of the Eastern and Western Range shall be in accordance with the Eastern and Western Range (EWR) 127-1 Range Safety Requirements.

The Federal Aviation Administration (FAA)/Associate Administrator for Commercial Space Transportation (AST) is responsible for the licensing of commercial space launches and permitting the operations of commercial launch sites. Mission-specific launch license processing shall be the responsibility of Boeing Delta Launch Services in accordance with Code of Federal Regulations, Title 14, Aeronautics and Space, Parts 400-499, Commercial Space Transportation.

Delta IV payload launch complex operations are conducted at Space Launch Complex 37B (CCAFS) and Space Launch Complex 6 (VAFB) in accordance with the applicable Operations Safety Plan and the Delta IV EWR 127-1 Range Safety Requirements (Tailored), MDC 99H1112.

### 9.1 REQUIREMENTS

The payload organization shall have a system safety program to effectively:

A. Identify and adequately describe all hazardous systems, assess associated mishap risks/mitigation measures, reduce mishap risks to acceptable levels, verify/document/track identified risks using a risk-management-process to support preparation of a mission-unique missile system prelaunch safety package (MSPSP) and payload safety review process in accordance with Appendix 3A of the Delta IV EWR 127-1 Tailored (T), and Appendix B of this guide.

B. Support an assessment to determine if a flight termination system is required.

C. Identify to Delta Launch Services any potential tailored requests to the Delta IV EWR 127-1 (T)—MDC 99H1112, prior to the mission orientation briefing.

D. Identify to Delta Launch Services any potential noncompliance requests to the Delta IV EWR 127-1 (T)—MDC 99H1112, prior to the mission orientation briefing.

# *Appendix A*
# *NATURAL AND TRIGGERED LIGHTNING LAUNCH COMMIT CRITERIA*

The Delta launch vehicle will not be launched even if only one of the following criteria is not met. If these constraints are not violated, yet other hazardous weather conditions exist, the launch weather officer will report the threat to the launch director. The launch director may order a hold at any time based on weather instability.

A. Do not launch if any type of lightning is detected within 10 nmi of the planned flight path within 30 min prior to launch, unless the meteorological condition that produced the lightning has moved more than 10 nmi away from the planned flight path.

B. Do not launch if the planned flight path will carry the vehicle:

(1) Through a cumulus cloud with its top between the +5.0°C and -5.0°C level unless:

(a) The cloud is not producing precipitation;

**-AND-**

(b) The horizontal distance from the farthest edge of the cloud top to at least one working field mill is less than the altitude of the -5.0°C level, or 3 nmi, whichever is smaller;

**-AND-**

(c) All field mill readings within 5 nmi of the flight path are between -100 V/m and +1000 V/m for the preceding 15 minutes.

(2) Through cumulus clouds with tops higher than the -5.0°C level.

(3) Through or within 5 nmi (horizontal or vertical) of the nearest edge of cumulus clouds with tops higher than the -10.0°C level.

(4) Through or within 10 nmi (horizontal or vertical) of the nearest edge of any cumulonimbus or thunderstorm cloud, including nontransparent parts of its anvil.

(5) Through or within 10 nmi (horizontal or vertical) of the nearest edge of a nontransparent detached anvil for the first hour after detachment from the parent thunderstorm or cumulonimbus cloud.

C. Do not launch if, for ranges equipped with a surface electric field mill network, at any time during the 15 min prior to launch time, the absolute value of any electric field intensity measurement at the ground is greater than 1000 V/m within 5 nmi of the flight path unless:

(1) There are no clouds within 10 nmi of the flight path except:

(a) Transparent clouds,

-OR-

(b) Clouds with tops below the +5.0°C level that have not been associated with convective clouds with tops above the -10.0°C level within the past 3 hr,

**-AND-**

(2) A known source of electric field (such as ground fog) that is occurring near the sensor, and that has been previously determined and documented to be benign, is clearly causing the elevated readings.

*Note: For confirmed failure of the surface field mill system, the countdown and launch may continue,* because *the other lightning launch commit criteria completely describe unsafe meteorological conditions.*

D. Do not launch if the flight path is through a vertically continuous layer of clouds with an overall depth of 4,500 ft or greater where any part of the clouds is located between the 0.0°C and -20.0°C levels.

E. Do not launch if the flight path is through any clouds that:

(1) Extend to altitudes at or above the 0.0°C level,

**-AND-**

(2) Are associated with disturbed weather that is producing moderate (29 dBz) or greater precipitation within 5 nmi of the flight path.

F. Do not launch if the flight path will carry the vehicle:

(1) Through any nontransparent thunderstorm or cumulonimbus debris cloud during the first 3 hr after the debris cloud formed from the parent cloud.

(2) Within 5 nmi (horizontal or vertical) of the nearest edge of a nontransparent thunderstorm or cumulonimbus debris cloud during the first 3 hr after the debris cloud formed from a parent cloud unless:

(a) There is at least one working field mill within 5 nmi of the debris cloud;

**-AND-**

(b) All electric field intensity measurements at the ground are between +1000 V/m and -1000 V/m within 5 nmi of the flight path during the 15 min preceding the launch time;

(c) The maximum radar return from the entire debris cloud is less than 10 dBz during the 15 minutes preceding launch time;

**-AND-**

(3) The start of the 3-hr period is determined as follows:

(a) **DETACHMENT**. If the cloud detaches from the parent cloud, the 3-hr period begins at the time when cloud detachment is observed or at the time of the last detected lightning discharge (if any) from the detached debris cloud, whichever is later.

(b) **DECAY OR DETACHMENT UNCERTAIN.** If it is not known whether the cloud is detached or the debris cloud forms from the decay of the parent cloud, the 3-hr period begins at the time when the parent cloud top decays to below the altitude of the -10°C level, or at the time of the last detected lightning discharge (if any) from the parent cloud or debris cloud, whichever is later.

G. Good Sense Rule: Even when constraints are not violated, if hazardous conditions exist, the launch weather officer will report the threat to the launch director. The launch director may order a hold at any time based on the weather threat.

H. Definitions/Explanations

(1) **Anvil:** Stratiform or fibrous cloud produced by the upper level outflow or blow-off from thunderstorms or convective clouds.

(2) **Cloud Edge:** The visible cloud edge is preferred. If this is not possible, then the 10 dBz radar cloud edge is acceptable.

(3) **Cloud Layer:** An array of clouds, not necessarily all of the same type, whose bases are approximately at the same level. Also, multiple arrays of clouds at different altitudes that are connected vertically by cloud element; e.g., turrets from one cloud to another. Convective clouds (e.g., clouds under Rule B above) are excluded from this definition unless they are imbedded with other cloud types.

(4) **Cloud Top:** The visible cloud top is preferred. If this is not possible, then the 13 dBz radar cloud top is acceptable.

(5) **Cumulonimbus Cloud:** Any convective cloud with any part above the -20.0°C temperature level.

(6) **Debris Cloud:** Any nontransparent cloud that has become detached from a parent cumulonimbus cloud or thunderstorm, or that results from the decay of a parent cumulonimbus cloud or thunderstorm.

(7) **Documented:** With respect to Rule C (2), "documented" means that sufficient data have been gathered on the benign phenomenon to both understand it and to develop procedures to evaluate it, and that the supporting data and evaluation have been reported in a technical report, journal article, or equivalent publication. For launches at the Eastern Range, copies of the documentation shall be maintained by the 45th Weather Squadron and KSC Weather Projects Office. The procedures used to assess the phenomenon during launch countdowns shall be documented and implemented by the 45th Weather Squadron.

(8) **Electric Field (for surface-based electric field mill measurements):** The 1-min arithmetic average of the vertical electric field (Ez) at the ground such as is measured by a ground-based field mill. The polarity of the electric field is the same as that of the potential gradient; that is, the polarity of the field at the ground is the same as that of the charge overhead.

(9) **Flight Path:** The planned flight trajectory including its uncertainties ("error bounds").

(10) **Precipitating Cloud:** Any cloud containing precipitation, producing virga, or having radar reflectivity greater than 13 dBz.

(11) **Thunderstorm:** Any cloud that produces lightning.

(12) **Transparent:** Synonymous with visually transparent. Sky cover through which higher clouds, blue sky, stars, etc., may be clearly observed from below. Also, sky cover through which terrain, buildings, etc., may be clearly observed from above. Sky cover through which forms are blurred, indistinct, or obscured is not transparent.

# *Appendix B*
# *PAYLOAD SAFETY REQUIREMENTS*

The interactive process between the payload manufacturers, Delta IV system safety, and range safety or other government agencies described in this section will ensure minimum impact to payload programs and reduce the cost and time required for the approval process.

Many payload systems are generic, meaning that they are built to a common bus structure, using a common launch vehicle and common range processing prelaunch and launch procedures. As a result, these generic payloads contain few changes to the baseline system, and the safety data can remain the same from one mission to the next.

To take advantage of previously approved payload systems and generic safety data, the requirements described below shall be followed; however, they may be modified to meet individual program requirements:

A. Delta IV system safety and the payload manufacturer, in conjunction with range safety or other government agency, shall conduct initial planning meetings to establish a payload approval process.

B. Once a baseline system has been approved, efforts will focus on specific changes for each new program or mission. NOTE: Existing and ongoing previously (range-safety) approved components, systems, and subsystems need not be resubmitted as part of data packages for review but referenced for traceability.

C. Delta IV system safety, the payload manufacturer, and range safety or other government agencies shall conduct a safety assessment of each new program or mission to define changes and/or additions that create new, uncontrolled hazards or that increase risks significantly.

D. Based on the joint safety assessment, the parties shall agree on the minimum required mission-unique documentation to be submitted for review and approval.

E. Data submittal and response times shall be established based on the joint safety assessment and modified only upon agreement of all parties.

F. The goal of the generic payload approval process is to achieve final range safety or other government agency approval at least 60 calendar days prior to payload arrival at Space Launch Complex 37B, (CCAFS) or 6 (VAFB).

## B.1 APPROVAL PROCESS FOR EXISTING PAYLOAD BUSES

For currently (range-safety) approved payload buses, the goal is to grant baseline approvals for generic buses during the first mission after implementation of this approach. Subsequent flights would use the joint assessment process to review and approve changes to the generic bus and/or payload additions for specific missions. Key to the approach is the safety assessment that is used to determine whether changes or additions have created any new uncontrolled hazards or have increased the risks significantly. The assessment results will be used to determine data required for review and approval requirements.

The approval process for existing payload buses is shown in Figure B-1 and described below.

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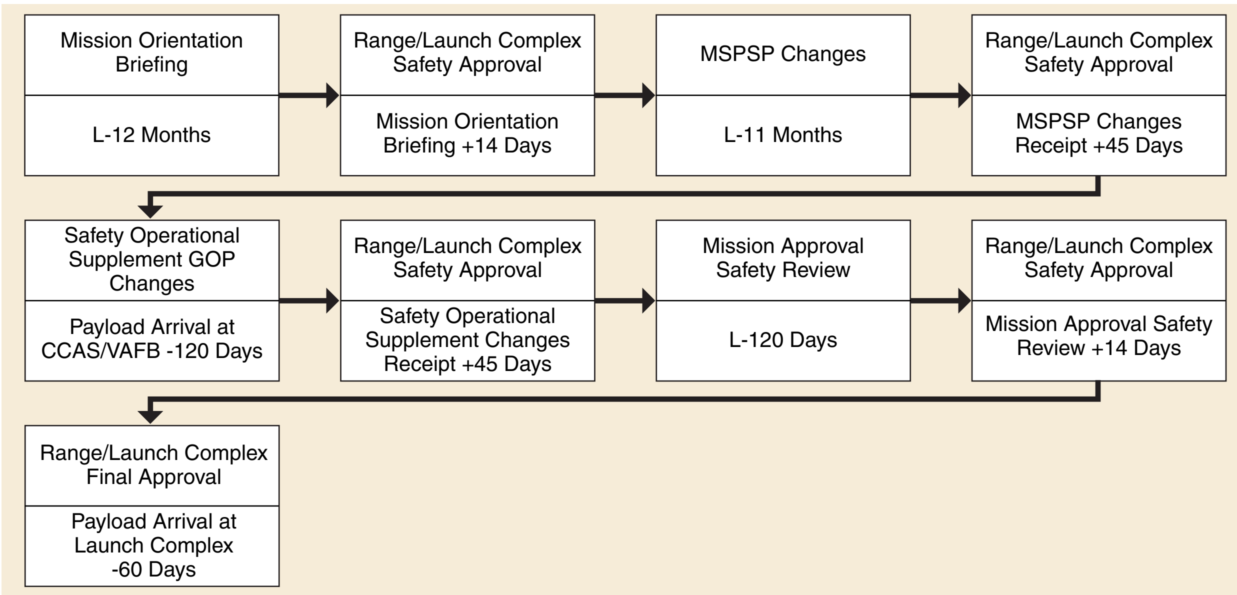



**Figure B-1. Approval Process for Existing Payload Buses**

### B.1.1 Mission Orientation Briefing

A. A mission orientation safety briefing shall be conducted for Delta IV system safety, range safety, and/or other government agencies for the mission. The briefing shall cover the following topics.

1. Changes to the payload bus.
2. Planned payload additions for the mission.
3. Changes to hazardous systems and operations (the focus of this review).
4. Changes to the launch vehicle.

B. Concurrence for both the mission concept and schedule for the remaining milestones shall be provided during the mission orientation safety briefing.

### B.1.2 Data Review and Approval

#### B.1.2.1 Mission-Unique Missile System Prelaunch Safety Package

A. A Delta IV system safety-prepared mission-unique missile system prelaunch safety package (MSPSP) shall be delivered to range safety and/or other government agencies approximately 12 months prior to launch and contain the payload data identified during the mission orientation safety briefing on the changes unique for the mission.

B. Delta IV system safety will coordinate with range safety and/or other government agencies to disposition responses after receipt of the data package.

#### B.1.2.2 Ground Operations Plan (GOP) and Hazardous and Safety-Critical Procedures

A. A Space Launch Complex 37B or 6 GOP supplement describing changes to approved operations and/or new or modified safety critical or hazardous procedures shall be delivered to range safety and other government agencies approximately 120 days prior to payload arrival on the range. NOTE: This supplement is required only if changes have been made to operations and procedures that affect hazardous levels or risks.

B. Delta IV system safety will coordinate with range safety and/or other government agencies to disposition responses after receipt of the data package.

#### B.1.2.3 Mission Approval Safety Review

A. A mission approval safety review shall be conducted approximately L-120 days to obtain range safety or other government agency approval for the launch vehicle and payload processing, transport of the payload to the launch complex, payload launch vehicle mating, and launch complex payload processing.

B. Delta IV system safety will coordinate resolution of any significant safety issues with range safety and/or other government agencies after the mission approval safety review.

#### B.1.2.4 Final Launch Approval

A. Final approval to proceed with launch vehicle and payload processing up to beginning the final countdown shall be provided by range safety and/or other government agencies at least 60 days prior to payload arrival at the launch complex. NOTE: Flight plan approval for a mission that involves public safety may not be granted until just prior to the launch readiness review (LRR) depending on the complexity of the public safety issue encountered.

## B.2 APPROVAL PROCESS FOR NEW PAYLOAD BUSES

For new payload buses, the goal is to grant baseline approvals for generic buses during the first mission after implementation of this approach. Subsequent flights would use the joint assessment process to review and approve changes to the generic bus and/or payload additions for specific missions. Key to the approach is the safety assessment that is used to determine whether changes or additions have created any new uncontrolled hazards or have increased the risks significantly. The assessment results will be used to determine data required for review and approval requirements.

The approval process for new payload buses is shown in Figure B-2 and described below.

### B.2.1 Concept Orientation Briefing and Safety Review

A. A payload concept orientation briefing shall be provided to Delta IV system safety, range safety, and other government agencies early in the conceptual phase of payload design development.

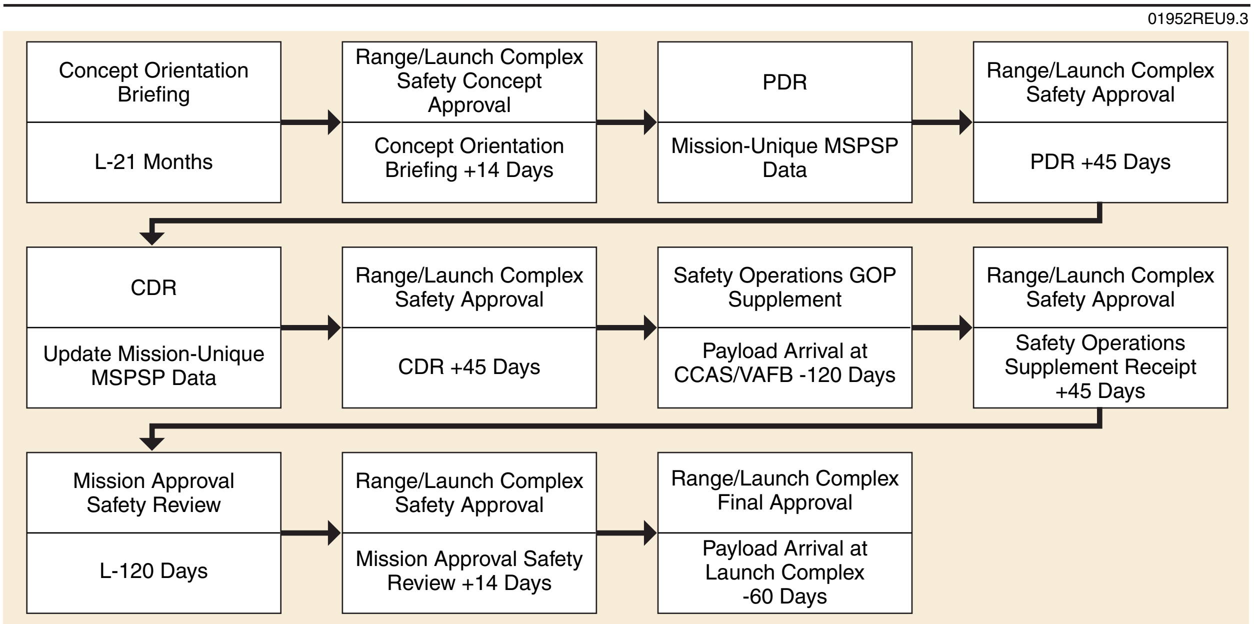



**Figure B-2. Approval Process for New Payload Buses**

B. The approval process shall be documented so that an audit trail can be established.

C. A payload concept orientation safety review shall be held in conjunction with this briefing, and approval of design concepts, schedule of safety submittals, and responses shall be documented.

### B.2.2 Preliminary Design Review

A. A payload preliminary design review (PDR) shall be held with Delta IV system safety to provide necessary mission-unique MSPSP data for initial submittal before the final payload design is completed and prelaunch processing is initiated.

B. Delta IV system safety will coordinate resolution of any significant safety issues with range safety and other government agencies.

### B.2.3 Critical Design and Data Review

A. A payload critical design review (CDR) shall be held with Delta IV system safety to provide the necessary mission-unique MSPSP data to grant final design approval and prelaunch processing initial procedure review.

B. Delta IV system safety will coordinate resolution of any significant safety issues with range safety and/or other government agencies

C. A mission-unique ground operations plan describing operations and containing safety-critical and hazardous procedures shall be delivered to range safety approximately 120 days prior to payload arrival on the range.

D. Delta IV system safety will coordinate resolution of any significant ground operations plan issues with range safety and other government agencies

### B.2.4 Mission Approval Safety Review

A. A mission approval safety review shall be conducted by Delta IV system safety approximately L-120 days to obtain range safety approval for launch vehicle and payload processing, transport to the payload launch pad, payload launch vehicle mating, and launch pad payload processing.

B. Delta IV system safety will coordinate resolution of any significant safety issues with range safety and other government agencies

### B.2.5 Final Launch Approval

Final approval to proceed with launch vehicle and payload processing up to beginning the final countdown shall be provided by range safety and/or other government agencies at least 60 days prior to payload arrival at the launch complex. NOTE: Flight plan approval for a mission that involves public safety may not be granted until just prior to the LRR, depending on the complexity of the public safety issue encountered. Typically, easterly launch azimuths from CCAFS can be approved at least 120 days prior to launch. Alternatively, high-inclination launches may require additional risk analyses that can lengthen the final flight plan approval process.

## B.3 INCIDENTAL RANGE SAFETY ISSUES

Incidental range safety/launch complex issues such as component failures, test failures, and the discovery of unforeseen hazards occurring after baseline approvals shall be worked in real time as part of the final approval process for an individual launch. Typically, these issues involve the launch vehicle and not the payload.

# Appendix C
# DELTA MISSIONS CHRONOLOGY

| Delta no. | Mission | Launch vehicle configuration | | Launch date | Results | Launch site |
|---|---|---|---|---|---|---|
| 280 | Simulated Payload | Delta III | 8930 | 8/23/00 | Successful | SLC-17B |
| 279 | GPS IIR-5 | Delta II | 7925 | 07/16/00 | Successful | SLC-17A |
| 278 | GPS IIR-4 | Delta II | 7925 | 05/10/00 | Successful | SLC-17A |
| 277 | Image | Delta II | 7326 | 03/25/00 | Successful | SLC-2W |
| 276 | Globalstar-7 (4) | Delta II | 7420-10C | 02/08/00 | Successful (2) | SLC-17B |
| 275 | GPS IIR-3 | Delta II | 7925 | 10/07/99 | Successful | SLC-17A |
| 274 | Globalstar-6 (4) | Delta II | 7420-10C | 08/17/99 | Successful (2) | SLC-17B |
| 273 | Globalstar-5 (4) | Delta II | 7420-10C | 07/25/99 | Successful (2) | SLC-17A |
| 272 | Globalstar-4 (4) | Delta II | 7420-10C | 07/10/99 | Successful (2) | SLC-17B |
| 271 | FUSE | Delta II | 7320-10C | 06/24/99 | Successful | SLC-17A |
| 270 | Globalstar-3 (4) | Delta II | 7420-10C | 06/10/99 | Successful (2) | SLC-17B |
| 269 | Orion-3 | Delta III | 8930 | 05/04/99 | Failed | SLC-17B |
| 268 | Landsat-7 | Delta II | 7920-10C | 04/15/99 | Successful | SLC-2W |
| 267 | P91 Argos/Sunsat/Orsted | Delta II | 7920-10 | 02/23/99 | Successful (1) | SLC-2W |
| 266 | Stardust | Delta II | 7426 | 02/07/99 | Successful | SLC-17A |
| 265 | Mars Polar Lander | Delta II | 7425 | 01/03/99 | Successful | SLC-17B |
| 264 | Mars Climate Orbiter | Delta II | 7425 | 12/11/98 | Successful | SLC-17A |
| 263 | Bonum-1 | Delta II | 7925 | 11/22/98 | Successful | SLC-17B |
| 262 | MS-11 (5) | Delta II | 7920-10C | 11/06/98 | Successful (2) | SLC-2W |
| 261 | Deep Space 1/SEDSAT | Delta II | 7326 | 10/24/98 | Successful (1) | SLC-17A |
| 260 | MS-10 (5) | Delta II | 7920-10C | 09/08/98 | Successful (2) | SLC-2W |
| 259 | GALAXY X | Delta III | 8930 | 08/26/98 | Failed | SLC-17B |
| 258 | THOR III | Delta II | 7925 | 06/09/98 | Successful | SLC-17A |
| 257 | MS-9 (5) | Delta II | 7920-10C | 05/17/98 | Successful (2) | SLC-2W |
| 256 | Globalstar-2 (4) | Delta II | 7420-10C | 04/24/98 | Successful (2) | SLC-17A |
| 255 | MS-8 (5) | Delta II | 7920-10C | 03/29/98 | Successful (2) | SLC-2W |
| 254 | MS-7 (5) | Delta II | 7920-10C | 02/18/98 | Successful (2) | SLC-2W |
| 253 | Globalstar-1 (4) | Delta II | 7420-10C | 02/14/98 | Successful (2) | SLC-17A |
| 252 | SKYNET 4D | Delta II | 7925 | 01/09/98 | Successful | SLC-17B |
| 251 | MS-6 (5) | Delta II | 7920-10C | 12/20/97 | Successful (2) | SLC-2W |
| 250 | MS-5 (5) | Delta II | 7920-10C | 11/08/97 | Successful (2) | SLC-2W |
| 249 | GPS II-28 | Delta II | 7925 | 11/05/97 | Successful | SLC-17A |
| 248 | MS-4 (5) | Delta II | 7920-10C | 09/26/97 | Successful (2) | SLC-2W |
| 247 | ACE | Delta II | 7920-8 | 08/25/97 | Successful | SLC-17A |
| 246 | MS-3 (5) | Delta II | 7920-10C | 08/20/97 | Successful (2) | SLC-2W |
| 245 | GPS IIR-2 | Delta II | 7925 | 07/22/97 | Successful | SLC-17A |
| 244 | MS-2 (5) | Delta II | 7920-10C | 07/09/97 | Successful (2) | SLC-2W |
| 243 | THOR IIA | Delta II | 7925 | 05/20/97 | Successful | SLC-17A |
| 242 | MS-1A (5) | Delta II | 7920-10C | 05/05/97 | Successful (2) | SLC-2W |
| 241 | GPS IIR-1 | Delta II | 7925 | 01/17/97 | Failed | SLC-17A |
| 240 | MARS PATHFINDER | Delta II | 7925 | 12/04/96 | Successful | SLC-17B |
| 239 | MARS GLOBAL SUR-VEYOR | Delta II | 7925 | 11/07/96 | Successful | SLC-17A |
| 238 | GPS II-27 | Delta II | 7925 | 09/12/96 | Successful | SLC-17A |
| 237 | GPS II-26 | Delta II | 7925 | 07/15/96 | Successful | SLC-17A |
| 236 | GALAXY IX | Delta II | 7925 | 05/23/96 | Successful | SLC-17B |
| 235 | MSX | Delta II | 7920-10 | 04/24/96 | Successful | SLC-2W |
| 234 | GPS II-25 | Delta II | 7925 | 03/27/96 | Successful | SLC-17B |

| Delta no. | Mission | Launch vehicle configuration | | Launch date | Results | Launch site |
|---|---|---|---|---|---|---|
| 233 | POLAR | Delta II | 7925-10 | 02/24/96 | Successful | SLC-2W |
| 232 | NEAR | Delta II | 7925-8 | 02/17/96 | Successful | SLC-17B |
| 231 | KOREASAT-2 | Delta II | 7925 | 01/14/96 | Successful | SLC-17B |
| 230 | XTE | Delta II | 7920-10 | 12/30/95 | Successful | SLC-17A |
| 229 | RADARSAT/SURFSAT | Delta II | 7920-10 | 11/04/95 | Successful (1) | SLC-2W |
| 228 | KOREASAT-1 | Delta II | 7925 | 08/05/95 | Failed | SLC-17B |
| 227 | WIND | Delta II | 7925-10 | 11/01/94 | Successful | SLC-17B |
| 226 | NAVSTAR II-24/SEDS-2 | Delta II | 7925 | 03/09/94 | Successful (1) | SLC-17A |
| 225 | GALAXY I-R | Delta II | 7925 | 02/19/94 | Successful | SLC-17B |
| 224 | NATO IVB | Delta II | 7925 | 12/07/93 | Successful | SLC-17A |
| 223 | NAVSTAR II-23 | Delta II | 7925 | 10/26/93 | Successful | SLC-17A |
| 222 | NAVSTAR II-22 | Delta II | 7925 | 08/30/93 | Successful | SLC-17A |
| 221 | NAVSTAR II-21/PMG | Delta II | 7925 | 06/26/93 | Successful (1) | SLC-17A |
| 220 | NAVSTAR II-20 | Delta II | 7925 | 05/12/93 | Successful | SLC-17A |
| 219 | NAVSTAR II-19/SEDS-1 | Delta II | 7925 | 03/29/93 | Successful (1) | SLC-17A |
| 218 | NAVSTAR II-18 | Delta II | 7925 | 02/02/93 | Successful | SLC-17A |
| 217 | NAVSTAR II-17 | Delta II | 7925 | 12/18/92 | Successful | SLC-17B |
| 216 | NAVSTAR II-16 | Delta II | 7925 | 11/22/92 | Successful | SLC-17A |
| 215 | DFS-3 KOPERNIKUS | Delta II | 7925 | 10/12/92 | Successful | SLC-17B |
| 214 | NAVSTAR II-15 | Delta II | 7925 | 09/09/92 | Successful | SLC-17A |
| 213 | SATCOM C-4 | Delta II | 7925 | 08/31/92 | Successful | SLC-17B |
| 212 | GEOTAIL/DUVE | Delta II | 6925 | 07/24/92 | Successful (1) | SLC-17A |
| 211 | NAVSTAR II-14 | Delta II | 7925 | 07/07/92 | Successful | SLC-17B |
| 210 | EUVE | Delta II | 6920-10 | 06/07/92 | Successful | SLC-17A |
| 209 | PALAPA B4 | Delta II | 7925-8 | 05/13/92 | Successful | SLC-17B |
| 208 | NAVSTAR I-13 | Delta II | 7925 | 04/09/92 | Successful | SLC-17B |
| 207 | NAVSTAR II-12R | Delta II | 7925 | 02/23/92 | Successful | SLC-17B |
| 206 | NAVSTAR II-11R/LOSAT-X | Delta II | 7925 | 07/03/91 | Successful (1) | SLC-17A |
| 205 | AURORA II | Delta II | 7925 | 05/29/91 | Successful | SLC-17B |
| 204 | ASC-2 | Delta II | 7925 | 04/12/91 | Successful | SLC-17B |
| 203 | INMARSAT 2 (F2) | Delta II | 6925 | 03/08/91 | Successful | SLC-17B |
| 202 | NATO-IVA | Delta II | 7925 | 01/07/91 | Successful | SLC-17B |
| 201 | NAVSTAR II-10 | Delta II | 7925 | 11/26/90 | Successful | SLC-17A |
| 200 | INMARSAT 2 (F2) | Delta II | 6925 | 10/30/90 | Successful | SLC-17B |
| 199 | NAVSTAR II-9 | Delta II | 6925 | 10/01/90 | Successful | SLC-17A |
| 198 | BSB-R2 | Delta II | 6925 | 08/17/90 | Successful | SLC-17B |
| 197 | NAVSTAR II-8 | Delta II | 6925 | 08/02/90 | Successful | SLC-17A |
| 196 | INSAT-1D | Delta | 4925-8 | 06/12/90 | Successful | SLC-17B |
| 195 | ROSAT | Delta II | 6920-10 | 06/01/90 | Successful | SLC-17A |
| 194 | PALAPA B2-R | Delta II | 6925-8 | 04/13/90 | Successful | SLC-17B |
| 193 | NAVSTAR II-7 | Delta II | 6925 | 03/25/90 | Successful | SLC-17A |
| 192 | LOSAT (LACE/RME) | Delta II | 6920-8 | 02/14/90 | Successful (2) | SLC-17B |
| 191 | NAVSTAR II-6 | Delta II | 6925 | 01/24/90 | Successful | SLC-17A |
| 190 | NAVSTAR II-5 | Delta II | 6925 | 12/11/89 | Successful | SLC-17B |
| 189 | COBE | Delta | 5920-8 | 11/18/89 | Successful | SLC-2W |
| 188 | NAVSTAR II-4 | Delta II | 6925 | 10/21/89 | Successful | SLC-17A |
| 187 | BSB-R1 | Delta | 4925-8 | 08/27/89 | Successful | SLC-17B |
| 186 | NAVSTAR II-3 | Delta II | 6925 | 08/18/89 | Successful | SLC-17A |
| 185 | NAVSTAR II-2 | Delta II | 6925 | 06/10/89 | Successful | SLC-17A |
| 184 | NAVSTAR II-1 | Delta II | 6925 | 02/14/89 | Successful | SLC-17A |
| 183 | DELTA STAR | Delta | 3920 | 03/24/89 | Successful | SLC-17B |
| 182 | PALAPA B2-P | Delta | 3920 | 03/20/87 | Successful | SLC-17B |

| Delta no. | Mission | Launch vehicle configuration | | Launch date | Results | Launch site |
|---|---|---|---|---|---|---|
| 181 | DOD#2 | Delta | 3910 | 02/08/88 | Successful | SLC-17B |
| 180 | DM-43 (DOD) | Delta | 3920 | 09/05/86 | Successful | SLC-17B |
| 179 | GOES-H | Delta | 3924 | 02/26/87 | Successful | SLC-17A |
| 178 | GOES-G | Delta | 3914 | 05/03/86 | Failed | SLC-17A |
| 177 | NATO-IIID | Delta | 3914 | 11/13/84 | Successful | SLC-17A |
| 176 | GALAXY-C | Delta | 3920 | 09/21/84 | Successful | SLC-17B |
| 175 | AMPTE (3) | Delta | 3924 | 08/16/84 | Successful (2) | SLC-17A |
| 174 | LANDSAT-D/UOSAT | Delta | 3920 | 03/01/84 | Successful (1) | SLC-2W |
| 173 | GALAXY-B | Delta | 3920 | 09/22/83 | Successful | SLC-17A |
| 172 | RCA-G | Delta | 3924 | 09/08/83 | Successful | SLC-17B |
| 171 | TELSTAR-3A | Delta | 3920 | 07/28/83 | Successful | SLC-17A |
| 170 | GALAXY-A | Delta | 3920 | 06/28/83 | Successful | SLC-17B |
| 169 | EXOSAT | Delta | 3914 | 05/26/83 | Successful | SLC-2W |
| 168 | GOES-F | Delta | 3914 | 04/28/83 | Successful | SLC-17A |
| 167 | RCA-F | Delta | 3924 | 04/11/83 | Successful | SLC-17B |
| 166 | IRAS/PIX-B | Delta | 3910 | 01/25/83 | Successful (1) | SLC-2W |
| 165 | RCA-E | Delta | 3924 | 10/27/82 | Successful | SLC-17B |
| 164 | TELESAT-F | Delta | 3920 | 08/26/82 | Successful | SLC-17B |
| 163 | LANDSAT-D | Delta | 3920 | 07/16/82 | Successful | SLC-2W |
| 162 | WESTAR-V | Delta | 3910 | 06/08/82 | Successful | SLC-17A |
| 161 | INSAT-1A | Delta | 3910 | 04/10/82 | Successful | SLC-17A |
| 160 | WESTAR-IV | Delta | 3910 | 02/25/82 | Successful | SLC-17A |
| 159 | RCA-C | Delta | 3910 | 01/15/82 | Successful | SLC-17A |
| 158 | RCA-D | Delta | 3910 | 11/19/81 | Successful | SLC-17A |
| 157 | SME/UOSAT | Delta | 2310 | 10/06/81 | Successful (1) | SLC-2W |
| 156 | SBS-B | Delta | 3910 | 09/24/81 | Successful | SLC-17A |
| 155 | DE-A/DE-B | Delta | 3913 | 08/03/81 | Successful (2) | SLC-2W |
| 154 | GOES-E | Delta | 3914 | 05/22/81 | Successful | SLC-17A |
| 153 | SBS-A | Delta | 3910 | 11/15/80 | Successful | SLC-17A |
| 152 | GOES-D | Delta | 3914 | 09/09/80 | Successful | SLC-17A |
| 151 | SMM | Delta | 3910 | 02/14/80 | Successful | SLC-17A |
| 150 | RCA-C | Delta | 3914 | 12/06/79 | Successful | SLC-17A |
| 149 | WESTAR-C | Delta | 2914 | 08/09/79 | Successful | SLC-17A |
| 148 | SCATHA | Delta | 2914 | 01/30/79 | Successful | SLC-17B |
| 147 | TELESAT-D | Delta | 3914 | 12/15/78 | Successful | SLC-17A |
| 146 | NATO-IIIC | Delta | 2914 | 11/18/78 | Successful | SLC-17B |
| 145 | NIMBUS-G/CAMEO | Delta | 2910 | 10/24/78 | Successful (1) | SLC-2W |
| 144 | ISEE-C | Delta | 2914 | 08/12/78 | Successful | SLC-17B |
| 143 | ESA-GEOS-2 | Delta | 2914 | 07/14/78 | Successful | SLC-17A |
| 142 | GOES-C | Delta | 2914 | 06/16/78 | Successful | SLC-17B |
| 141 | OTS-2 | Delta | 3914 | 05/11/78 | Successful | SLC-17A |
| 140 | BSE | Delta | 2914 | 04/07/78 | Successful | SLC-17B |
| 139 | LANDSAT-C/OSCAR/PIX-A | Delta | 2910 | 03/05/78 | Successful (2) | SLC-2W |
| 138 | IUE | Delta | 2914 | 01/26/78 | Successful | SLC-17A |
| 137 | CS | Delta | 2914 | 12/14/77 | Successful | SLC-17B |
| 136 | METEOSAT | Delta | 2914 | 11/22/77 | Successful | SLC-17A |
| 135 | ISEE-A/ISEE-B | Delta | 2914 | 10/22/77 | Successful (2) | SLC-17B |
| 134 | OTS | Delta | 3914 | 09/13/77 | Failed | SLC-17A |
| 133 | SIRIO | Delta | 2313 | 08/25/77 | Successful | SLC-17B |
| 132 | GMS | Delta | 2914 | 07/14/77 | Successful | SLC-17B |
| 131 | GOES-B | Delta | 2914 | 06/16/77 | Successful | SLC-17B |

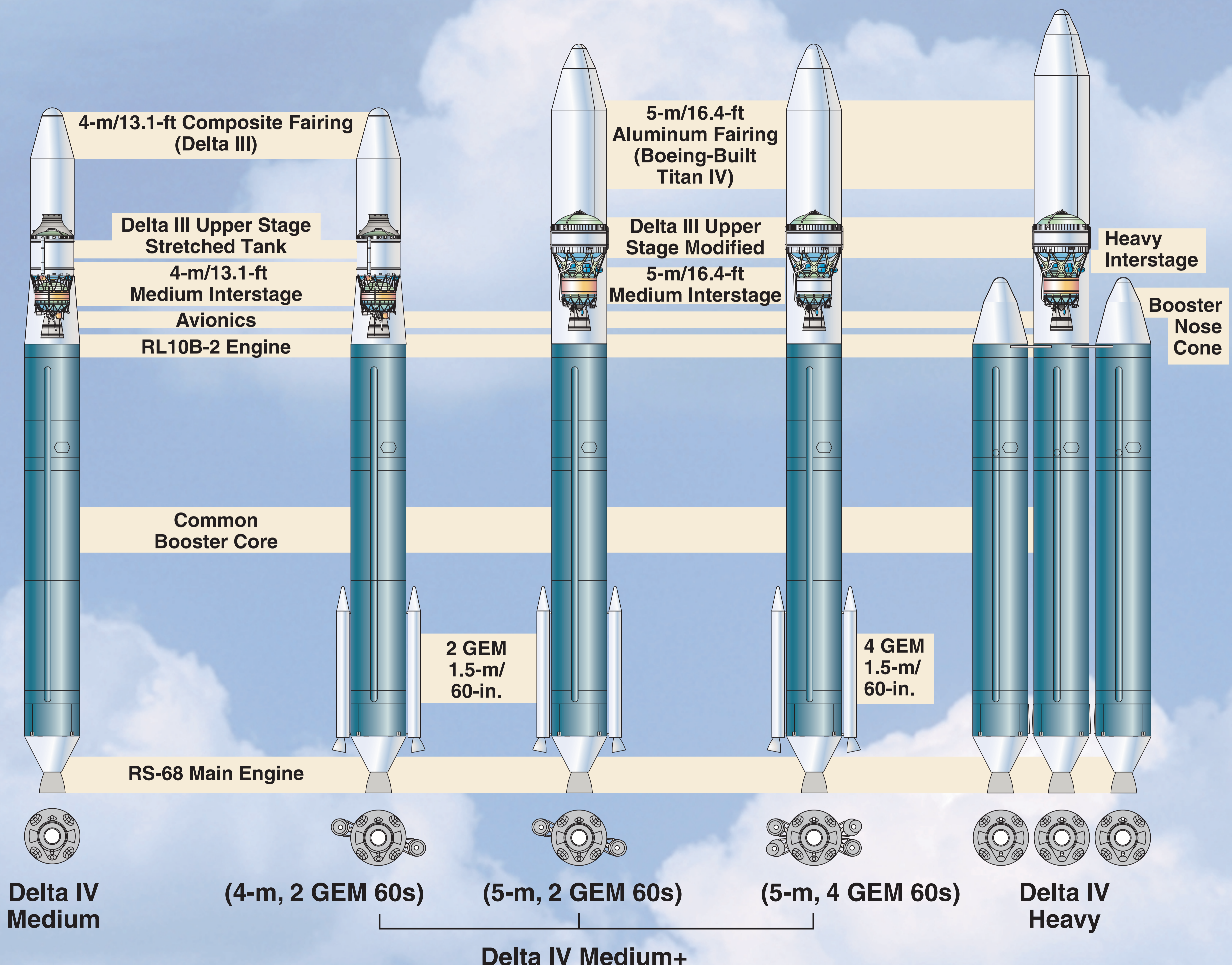
| Delta no. | Mission | Launch vehicle configuration | | Launch date | Results | Launch site |
|---|---|---|---|---|---|---|
| 130 | ESRO-GEOS | Delta | 2914 | 04/20/77 | Failed | SLC-17B |
| 129 | PALAPA-B | Delta | 2914 | 03/10/77 | Successful | SLC-17A |
| 128 | NATO -IIIB | Delta | 2914 | 01/27/77 | Successful | SLC-17B |
| 127 | MARISAT-C | Delta | 2914 | 10/14/76 | Successful | SLC-17A |
| 126 | ITOS-E2 | Delta | 2310 | 07/29/76 | Successful | SLC-2W |
| 125 | PALAPA-A | Delta | 2914 | 07/08/76 | Successful | SLC-17A |
| 124 | MARISAT-B | Delta | 2914 | 06/09/76 | Successful | SLC-17A |
| 123 | LAGEOS | Delta | 2913 | 05/04/76 | Successful | SLC-2W |
| 122 | NATO-IIIA | Delta | 2914 | 04/22/76 | Successful | SLC-17B |
| 121 | RCA-B | Delta | 3914 | 03/26/76 | Successful | SLC-17A |
| 120 | MARISAT-A | Delta | 2914 | 02/19/76 | Successful | SLC-17B |
| 119 | CTS | Delta | 2314 | 01/17/76 | Successful | SLC-17B |
| 118 | RCA-A | Delta | 3914 | 12/12/75 | Successful | SLC-17A |
| 117 | AE-E | Delta | 2910 | 11/19/75 | Successful | SLC-17B |
| 116 | GOES-A | Delta | 2914 | 10/16/75 | Successful | SLC-17B |
| 115 | AE-D | Delta | 2910 | 10/06/75 | Successful | SLC-2W |
| 114 | SYMPHONIE-B | Delta | 2914 | 08/26/75 | Successful | SLC-17A |
| 113 | COS-B | Delta | 2913 | 08/08/75 | Successful | SLC-2W |
| 112 | OSO-I | Delta | 1910 | 06/21/75 | Successful | SLC-17B |
| 111 | NIMBUS-F | Delta | 2910 | 06/12/75 | Successful | SLC-2W |
| 110 | TELESAT-C | Delta | 2914 | 05/07/75 | Successful | SLC-17B |
| 109 | GEOS-C | Delta | 1410 | 04/09/75 | Successful | SLC-2W |
| 108 | SMS-B | Delta | 2914 | 02/06/75 | Successful | SLC-17B |
| 107 | ERTS-B | Delta | 2910 | 01/22/75 | Successful | SLC-2W |
| 106 | SYMPHONIE-A | Delta | 2914 | 12/18/74 | Successful | SLC-17B |
| 105 | SKYNET IIB | Delta | 2313 | 11/22/74 | Successful | SLC-17B |
| 104 | ITOS-G/OSCAR-7/INTA-SAT | Delta | 2310 | 11/15/74 | Successful (1) | SLC-2W |
| 103 | WESTAR-B | Delta | 2914 | 10/10/74 | Successful | SLC-17B |
| 102 | SMS-A | Delta | 2914 | 05/17/74 | Successful | SLC-17B |
| 101 | WESTAR-A | Delta | 2914 | 04/13/74 | Successful | SLC-17B |
| 100 | SKYNET IIA | Delta | 2313 | 01/18/74 | Failed | SLC-17B |
| 99 | AE-C | Delta | 1900 | 12/15/73 | Successful | SLC-2W |
| 98 | ITOS-F | Delta | 300 | 11/06/73 | Successful | SLC-2W |
| 97 | IMP-J | Delta | 2913 | 10/25/73 | Successful | SLC-17B |
| 96 | ITOS-E | Delta | 300 | 07/16/73 | Failed | SLC-2W |
| 95 | RAE-B | Delta | 1913 | 06/10/73 | Successful | SLC-17B |
| 94 | TELESAT-B | Delta | 1913 | 04/20/73 | Successful | SLC-17B |
| 93 | NIMBUS-E | Delta | 900 | 12/10/72 | Successful | SLC-2W |
| 92 | TELESAT-A | Delta | 1913 | 11/09/72 | Successful | SLC-17B |
| 91 | ITOS-D/AMSAT-OSCAR-6 | Delta | 300 | 10/15/72 | Successful (1) | SLC-2W |
| 90 | IMP-H | Delta | 1604 | 09/22/72 | Successful | SLC-17B |
| 89 | ERTS-A | Delta | 900 | 07/23/72 | Successful | SLC-2W |
| 88 | TD-1 | Delta | DSV-3L | 03/11/72 | Successful | SLC-2E |
| 87 | HEOS-A2 | Delta | DSV-3L | 01/31/72 | Successful | SLC-2E |
| 86 | ITOS-B | Delta | DSV-3L | 10/21/71 | Failed | SLC-2E |
| 85 | OSO-H/TETRS-4 | Delta | DSV-3L | 09/29/71 | Successful (1) | SLC-17A |
| 84 | ISIS-B | Delta | DSV-3E | 03/31/71 | Successful | SLC-2E |
| 83 | IMP-1 | Delta | DSV-3L | 03/13/71 | Successful | SLC-17A |
| 82 | NATO-B | Delta | DSV-3L | 02/02/71 | Successful | SLC-17A |
| 81 | ITOS-A | Delta | DSV-3L | 12/11/70 | Successful | SLC-2W |
| 80 | IDCPS/A-B | Delta | DSV-3L | 08/19/70 | Successful | SLC-17A |

| Delta no. | Mission | Launch vehicle configuration | | Launch date | Results | Launch site |
|---|---|---|---|---|---|---|
| 79 | INTELSAT III H | Delta | DSV-3L | 07/23/70 | Successful | SLC-17A |
| 78 | INTELSAT III G | Delta | DSV-3L | 04/22/70 | Successful | SLC-17A |
| 77 | NATO-A | Delta | DSV-3L | 03/20/70 | Successful | SLC-17A |
| 76 | TIROS-M/OSCAR-5 | Delta | DSV-3L | 01/23/70 | Successful (1) | SLC-2W |
| 75 | INTELSAT III F | Delta | DSV-3L | 01/14/70 | Successful | SLC-17A |
| 74 | IDCSP/A | Delta | DSV-3L | 11/21/69 | Successful | SLC-17A |
| 73 | PIONEER E/TETRS-3 | Delta | DSV-3L | 08/27/69 | Failed (1) | SLC-17A |
| 72 | OSO-G/PAC | Delta | DSV-3L | 08/09/69 | Successful (1) | SLC-17A |
| 71 | INTELSAT III E | Delta | DSV-3L | 07/25/69 | Failed | SLC-17A |
| 70 | BIOS-D | Delta | DSV-3L | 06/28/69 | Successful | SLC-17A |
| 69 | IMP-G | Delta | DSV-3E | 06/21/69 | Successful | SLC-2W |
| 68 | INTELSAT III D | Delta | DSV-3L | 05/21/69 | Successful | SLC-17A |
| 67 | TOS-G | Delta | DSV-3E | 02/26/69 | Successful | SLC-17B |
| 66 | INTELSAT III B | Delta | DSV-3L | 02/05/69 | Successful | SLC-17A |
| 65 | ISIS-A | Delta | DSV-3E | 01/29/69 | Successful | SLC-2E |
| 64 | OSO-F | Delta | DSV-3C | 01/22/69 | Successful | SLC-17B |
| 63 | INTELSAT III C | Delta | DSV-3L | 12/18/68 | Successful | SLC-17A |
| 62 | TOS-E2/F | Delta | DSV-3L | 12/15/68 | Successful | SLC-2E |
| 61 | HEOS-A | Delta | DSV-3E | 12/05/68 | Successful | SLC-17B |
| 60 | PIONEER D/TETRS-2 (TEST & TRAINING SATELLITE) | Delta | DSV-3E | 11/08/68 | Successful (1) | SLC-17B |
| 59 | INTELSAT III A | Delta | DSV-3L | 09/18/68 | Failed | SLC-17A |
| 58 | TOS-E | Delta | DSV-3L | 08/16/68 | Successful | SLC-2E |
| 57 | RAE-A | Delta | DSV-3E | 07/14/68 | Successful | SLC-2E |
| 56 | GEOS-B | Delta | DSV-3E | 01/11/68 | Successful | SLC-2E |
| 55 | PIONEER C/TTS (TEST & TRAINING SATELLITE) | Delta | DSV-3E | 12/13/67 | Successful (1) | SLC-17B |
| 54 | TOS-C | Delta | DSV-3E | 11/10/67 | Successful | SLC-2E |
| 53 | OSO-D | Delta | DSV-3C | 10/18/67 | Successful | SLC-17B |
| 52 | INTELSAT II F4 | Delta | DSV-3E | 09/27/67 | Successful | SLC-17B |
| 51 | BIOS-B | Delta | DSV-3G | 09/07/67 | Successful | SLC-17B |
| 50 | IMP-E | Delta | DSV-3E | 07/19/67 | Successful | SLC-17B |
| 49 | IMP-F | Delta | DSV-3E | 05/24/67 | Successful | SLC-2E |
| 48 | TOS-D | Delta | DSV-3E | 04/20/67 | Successful | SLC-2E |
| 47 | INTELSAT II F3 | Delta | DSV-3E | 03/22/67 | Successful | SLC-17B |
| 46 | OSO-E1 | Delta | DSV-3C | 03/08/67 | Successful | SLC-17A |
| 45 | TOS-B | Delta | DSV-3E | 01/26/67 | Successful | SLC-2E |
| 44 | INTELSAT II F2 | Delta | DSV-3E | 01/11/67 | Successful | SLC-17B |
| 43 | BIOS-A | Delta | DSV-3C | 12/14/66 | Successful | SLC-17A |
| 42 | INTELSAT II F1 | Delta | DSV-3E | 10/26/66 | Successful | SLC-17B |
| 41 | TOS-A | Delta | DSV-3E | 10/02/66 | Successful | SLC-2E |
| 40 | PIONEER B | Delta | DSV-3E | 08/17/66 | Successful | SLC-17A |
| 39 | IMP-D | Delta | DSV-3E | 07/01/66 | Successful | SLC-17A |
| 38 | AE-B | Delta | DSV-3C | 05/25/66 | Successful | SLC-17B |
| 37 | OT-2 | Delta | DSV-3E | 02/28/66 | Successful | SLC-17B |
| 36 | OT-3 | Delta | DSV-3C | 02/03/66 | Successful | SLC-17A |
| 35 | PIONEER A | Delta | DSV-3E | 12/16/65 | Successful | SLC-17A |
| 34 | GEOS-A | Delta | DSV-3E | 11/06/65 | Successful | SLC-17A |
| 33 | OSO-C | Delta | DSV-3C | 08/25/65 | Failed | SLC-17B |
| 32 | OT-1 | Delta | DSV-3C | 07/01/65 | Successful | SLC-17B |
| 31 | IMP-C | Delta | DSV-3C | 05/29/65 | Successful | SLC-17B |
| 30 | COMSAT-1 | Delta | DSV-3D | 04/06/65 | Successful | SLC-17A |

| Delta no. | Mission | Launch vehicle configuration | | Launch date | Results | Launch site |
|---|---|---|---|---|---|---|
| 29 | OSO-B2 | Delta | DSV-3C | 02/03/65 | Successful | SLC-17B |
| 28 | TIROS-I | Delta | DSV-3C | 01/22/65 | Successful | SLC-17A |
| 27 | S-3C | Delta | DSV-3C | 12/21/64 | Successful | SLC-17A |
| 26 | IMP-B | Delta | DSV-3C | 10/03/64 | Successful | SLC-17A |
| 25 | SYNCOM-C | Delta | DSV-3D | 08/19/64 | Successful | SLC-17A |
| 24 | S-66 | Delta | DSV-3B | 03/19/64 | Failed | SLC-17A |
| 23 | RELAY | Delta | DSV-3B | 01/21/64 | Successful | SLC-17B |
| 22 | TIROS-H | Delta | DSV-3B | 12/21/63 | Successful | SLC-17B |
| 21 | IMP-A | Delta | DSV-3C | 11/26/63 | Successful | SLC-17B |
| 20 | SYNCOM A-26 | Delta | DSV-3B | 07/26/63 | Successful | SLC-17A |
| 19 | TIROS-G | Delta | DSV-3B | 06/19/63 | Successful | SLC-17B |
| 18 | TELSTAR-2 | Delta | DSV-3B | 05/07/63 | Successful | SLC-17B |
| 17 | S-6 | Delta | DSV-3B | 04/02/63 | Successful | SLC-17A |
| 16 | SYNCOM-A-25 | Delta | DSV-3B | 02/14/63 | Successful | SLC-17B |
| 15 | RELAY A-15 | Delta | DSV-3B | 12/13/62 | Successful | SLC-17A |
| 14 | S-3B | Delta | DSV-3A | 10/27/62 | Successful | SLC-17B |
| 13 | S-3A | Delta | DSV-3A | 10/02/62 | Successful | SLC-17B |
| 12 | TIROS-F | Delta | DM-19 | 09/18/62 | Successful | SLC-17A |
| 11 | TELSTAR | Delta | DM-19 | 07/10/62 | Successful | SLC-17B |
| 10 | TIROS-E | Delta | DM-19 | 06/19/62 | Successful | SLC-17A |
| 9 | S-51 | Delta | DM-19 | 04/26/62 | Successful | SLC-17A |
| 8 | S-16 | Delta | DM-19 | 03/07/62 | Successful | SLC-17A |
| 7 | TIROS-D | Delta | DM-19 | 02/08/62 | Successful | SLC-17A |
| 6 | S-3 | Delta | DM-19 | 08/15/61 | Successful | SLC-17A |
| 5 | TIROS-A3 | Delta | DM-19 | 07/12/61 | Successful | SLC-17A |
| 4 | P-14 | Delta | DM-19 | 03/25/61 | Successful | SLC-17A |
| 3 | TIROS-2 | Delta | DM-19 | 11/23/60 | Successful | SLC-17A |
| 2 | ECHO 1A | Delta | DM-19 | 08/12/60 | Successful | SLC-17A |
| 1 | ECHO 1 | Delta | DM-19 | 05/13/60 | Failed | SLC-17A |

(1) Secondary payload mission
(2) Multiple payloads mission
Space Launch Complex 2E and 2W are in WR
Space Launch 17A and 17B are in ER

# The Delta IV Family of Launch Vehicles

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